Concrete

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A New, Important Series of Articles on The Question, "What IS Portland Cement?"

CONCRETE considers itself particularly fortunate to be permitted to present to its readers what is perhaps one of the most important technical papers that has been released in recent years.

In it an authority tells of attempts to learn the secrets of what actually happens when portland cement is made.

When engineers had found a material possessing properties of portland cement as we know it today, they naturally concentrated their attention on the problem of how to make the best use of it. The most important immediate need was to study the technique of its concrete making qualities. Research followed research until today there are formidable libraries of treatises and reports on the uses and physical properties of portland cement.

How The Story Will Appear

- *Part I, July—Early Views and Methods of Experimentation.*
- *Part II, August—The Introduction of the Scientific Method.*
- *Part III, September—Development of Proportioning Formulas.*
- *Part IV, October—Hypothesis of Solid Solution.*
- *Part V, November—Constitutional Formulas of Cement Constituents.*
- *Part VI, December—The Thermal Reactions of Clinker Formation.*
- *Part VII, January—Phase Equilibria and the Modern Viewpoint.*

IN contrast to the prevalence of material on the uses of cement, is the limited data of a reliable character resulting from investigations in the constitution of the cement itself. Certainly, however, much has been contributed in the past by the learned investigators of a former day. The series of contributions beginning in CONCRETE with this issue bear witness to the remarkable work of earlier investigators who were forced to rely upon inadequate equipment in the conduct of their work. The remarkable thing about the history of the development of our knowledge on the constitution of Portland Cement Clinker is not its meagerness, but is the high quality of the work actually accomplished with the tools available.

The time has come when it is necessary to continue investigations on this important problem. The technique of concrete making has developed from crude mass work to careful scientific design for predetermined strengths on important structural work. This refinement of design and progress in concrete control brought with it the need for better understanding of the cement itself. With the assembling and trying out of the much needed equipment at the National Bureau of Standards, there may be discoveries of hitherto unknown phenomena regarding the behavior of portland cement.

THE first important step in this fundamental research has now been taken, as is witnessed by the establishment of the above mentioned Portland Cement Association Fellowship at the National Bureau of Standards, having as its object an investigation into the constitution of portland cement. The program of research is to include a review of all the work that has been accomplished up to the present and following this will be inaugurated studies on (a) Phase Equilibria, (b) Synthetic Combinations, (c) Hydration and Hydrolysis, (d) Optics and Mineralogy, (e) Kinetics and Thermoreactions, (f) Chemical Preparations and Analyses, (g) Physical Studies, (h) Colloidal and Crystalloidal Behavior and (j) X-Ray Studies.

This contribution is the first of a series pertaining to the constitution of Portland Cement Clinker, to be released on the researches made under the Portland Cement Association Fellowship at the National Bureau of Standards and is published by permission of the Portland Cement Association and the Director of the National Bureau of Standards of the United States Department of Commerce.

This research—A Digest of the Literature of the Constitution of Portland Cement Clinker, has been completed and publication begins in this issue of CONCRETE on Page 14.

The Constitution of Portland Cement Clinker*

Part I of a Digest of the Literature on this Subject—Ancient Uses of Cements—Early European Researches and Experiments — Discovery of Portland Cement — Chemical Theories and Investigations—Summary of Early Investigations

By R. H. BOGUE

Foreword

FROM the days of antiquity to the present time man has utilized cementitious materials in the construction of dwelling places, dams, roadways, bridges, et cetera. The natives of the Southwest still use the primitive material, "adobe" clay. As the necessity for stronger and more weather-resistant materials developed, other substances were found or produced. Limestone was burned by the ancients and mixed with sand and sometimes a volcanic scoria "puzzolana" to produce a cement which has served in the construction of great architectural masterpieces. The utilization of argillaceous limestone or the addition of clay to the limestone and the application of higher temperatures have led to the development of the much stronger hydraulic product which is now known as portland cement.

Although the discovery of the superior qualities imparted to a cement by the above changes was probably accidental, yet these qualities have been so impressive, and the product so extraordinarily important to our modern industrial development, that much study has been brought to bear upon the nature of this cement. Many of the ablest students of their day have given years, or even their lives, to the pursuit of this problem. In addition, the literature on portland cement contains many hundreds of contributions often of importance but, as in all other subjects, frequently also of no value due to unsound premises, inadequate experimentation or faulty deduction.

The literature is much too voluminous and too widely scattered to be easily perused even by those most concerned with the subject. Furthermore, the theories presented are so divergent and frequently the bases for them so unrelated that, even if the literature were all read, a great deal of intensive study would be required thoroughly to digest, to correlate and to orient the numerous theories in an orderly manner in the mind.

For these reasons it has seemed desirable to present a brief review of the more important contributions that have been made on the constitution of portland cement. The review is not exhaustive but is probably fairly representative. The subject matter is presented usually in chronological sequence. In order to limit the present report strictly to the subject given, the very important questions of the setting and hardening of cement have been omitted entirely in this paper.

The writer wishes expressly to acknowledge the assistance rendered in the preparation of this review by the members of the staff of the Portland Cement Association Fellowship, through the abstracts, translations, addresses and discussions provided by them.

Part I.—Early Views and Methods of Experimentation

THE Romans have a reputation for the production of a cement which has proven remarkably resistant to the action of the elements during the centuries through which it has served. A great curious bridge and aqueduct called the Pont du Gard was built during the reign of Emperor Augustus of Rome near the city of Nimes in Southern France. This is sometimes spoken of as one of the seven wonders of the world. It consists of three tiers, each built upon columns supported by the tier below. The upper tier served as a trough to carry water for cities many miles distant. This trough was lined with cement which today is exceedingly hard and very firm. Other great projects were constructed, as the Pantheon and the Coliseum the cementing materials in which have resisted in a remarkable degree the destructive agents of the ages.

But if we may judge the nature of the original raw materials from the writings of Vitruvius[1] or Alberti,[2] or from the present analyses of the products, we cannot believe that the Romans were in possession of any marvelous secrets of mixing which have since been lost. These early cements appear to have been composed of mixtures of slaked lime and sand, particularly a volcanic scoria, *puzzolana.*

Little Progress Made

There seems to have been very little progress in the art or knowledge of cement manufacture for eighteen hundred years. In 1756 John Smeaton,[3] an English engineer, made a study of limes preparatory to the erection of the Eddystone Lighthouse. He made the most important discovery that limestones which contain a considerable proportion of clay are distinctly superior to the purer limestones for the making of hydraulic cements. Although little attention was given to this discovery for many years, it must be regarded as one of the distinctly unique and far-reaching findings in cement history.

Higgins[4] in 1780 contributed notably to the art of applying mortars, but he failed to take cognizance of the work of Smeaton. He records, however, his own observation that

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*Paper No. 3 of the Portland Cement Association Fellowship at the Bureau of Standards.

[1] P. Vitruvius, "Architecture," translated from the Latin by J. Gwilt. John Weale, London, 1860. "The Ten Books on Architecture," translated from the Latin by M. H. Morgan. Harvard Univ. Press, Cambridge, 1914.

[2] Leoni Baptista Alberti. *Cf.* "Appeal to the Public," Liardet, 1778.

[3] John Smeaton, "Narrative of the Building of the Eddystone Lighthouse," Longman, Hurst, Rees, Orme and Brown. 2nd ed., London, 1813.

[4] Bry. Higgins, "Experiments and Observations on Calcareous Cements," T. Cadell, London, 1780.

> When limestone or chalk is suddenly heated to the highest degree . . . it vitrifies in the parts which touch the fire vessels or furnace or fuel and the whole of it becomes incapable of slaking freely or acting like lime. Limestone is the more apt to vitrify in such circumstances as it contains more gypseous or argillaceous particles, and oyster shells or cockle shells vitrify more easily than limestone or chalk.

It was also in 1780 that Bergman,[5] a Swedish chemist, found by analysis that the lime of Lena in Upland contained about 2 per cent of manganese. He at once attributed the property possessed by this lime of hardening under water to the presence of manganese. This view seems to have prevailed for many years, but in 1806 Vitalis,[6] professor of chemistry and secretary of the Academy at Rouen, revised the theory of Smeaton and wrote:

> It results from the analyses that the limestones of Senonches and of St. Catherine were true marine limestones in which the chalk predominated. It is true, however, that the clay plays a very important role. It is that constituent which in my opinion renders hydraulic the lime of these two kinds of rocks, from which it follows that the presence of manganese oxide is, at least, not the only condition for obtaining a lime of that kind. However, these analyses show that the rocks having this action do not contain manganese.

These observations were confirmed by Le Massen in 1807 and again by Collet Descotels,[7] chief engineer and Professor of the School of Mines, in 1813. The latter wrote:

> That silica which is not attacked or dissolved by acid in the limestone of Senonches remains intact in the limes made from this stone. The silica so found in the lime of Senonches is consequently in a state highly suited for reaction with chemical agents. It appears very probable that the essential condition for a limestone to furnish good lean lime is that it contain a large quantity of siliceous material disseminated in very fine particles, for it seems little probable that the small amounts of alumina, magnesia, and ferric oxide that are present could have any appreciable influence on these properties.

These scattered opinions were brought to a focus by Vicat[8] who, in 1818, published his justly celebrated memoire on "Calcareous Mortars and Cements." Like the others of his day, the investigations of Vicat were concerned mainly with the processes of setting and hardening, but he made also a study on the manner of burning and the raw materials of the cements.

Vicat's Experiments

Vicat classified all limestones into five groups which he denoted as forming (1) rich limes, (2) poor limes, (3) slightly hydraulic limes, (4) hydraulic limes, and (5) eminently hydraulic limes. With reference to the importance of clay or sand in the limestone and the influence of these on the hydraulic properties of the product, Vicat wrote:

> In the present state of our knowledge regarding the different varieties of lime, it is impossible to say whether there exist certain determinate proportions of silica alone, or of silica and alumina, or of silica and magnesia, etc., which by their intimate association with the same quantity of calcareous matter are capable of producing limes of equal energy. But one thing is certain, and this is important to recollect, that no perfectly hydraulic mortar exists without silica, and all lime which can be so denominated is found by chemical analysis to contain a certain quantity of clay, made up of silica and alumina in proportions similar to those which constitute the ordinary clays.

In recognition of the value of clays in the raw mixture, Vicat proceeded to prepare hydraulic limes in two ways. The best of these, he states, was to mix clay in certain proportions with rich lime and calcine the mixture. This he called *artificial lime twice kilned*. A cheaper method, and one giving a somewhat poorer product, was to mix clay with a crushed limestone or chalk. But the mixing and pulverizing, being less perfect than in the former case, the product was less uniform. And he adds with surprising modernism:

> We see that by being able to regulate the proportions, we can give to the factitious lime whatever degree of energy we please, and cause it at pleasure to equal or surpass the natural limes.

Discovery of Portland Cement

The name *Portland Cement* was given in 1824 by an Englishman named Joseph Aspdin,[9] by virtue of the close resemblance his product bore to a natural building rock occurring near the town of Portland in England. To Aspdin is commonly given the credit for the invention of portland cement because it was he who first obtained a patent on it. But like many so called discoveries, portland cement was not discovered suddenly or by one man. The evolution of this cement had been a gradual process, and many chemists and engineers had contributed information which led inevitably to the final production of this new cement. Manufacturers had been brought to a realization that limestone mixed naturally or artificially with definite and fixed amounts of clay gave, when burned, a product of higher hydraulic quality than a limestone without clay. They had learned by experiment and experience the approximate proportions which gave the best product and which could most expeditiously be handled. They had learned that burning at a high temperature gave a clinker which, when ground, was more hydraulic than a similar composition burned at a low temperature, and that the finer ground raw mixtures produced a more nearly uniform and better burned clinker than the coarsely ground mixtures.

Aspdin, however, forced the temperature of burning to still higher levels, and controlled his composition and grinding more carefully than was the common practice. As a result he obtained a cement which many before him had striven for, an hydraulic cement "as hard as Portland stone."

Research Lags

The manner of combination of the clay with the lime, by which process an hydraulic cement was formed, seems not to have interested many of the earlier engineers or manufacturers. They were concerned over the materials and the technique of manufacture and utilization, but not so greatly over the underlying causes of why certain combinations of materials and technique produced specific results. As stated by John Grant[10] in 1865:

> The manufacture of portland cement is not one of complex character although it requires the exercise of extreme care in the admixture of its two simple and well-known ingredients, clay and chalk.

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[5] Bergman, 1780. *Cf.* E. Leduc, *Bull. soc. encour. ind. natl.*, (1911), 280.

[6] Vitalis, 1806. *Cf.* E. Leduc, *Op. cit.*

[7] Collet Descotels, 1813. *Cf.* E. Leduc, *Op. cit.*

[8] L. J. Vicat, "A Practical and Scientific Treatise on Calcareous Mortars and Cements, Artificial and Natural," translated by J. T. Smith, John Weale, London, 1837.

[9] Joseph Aspdin, British Patent, 1824.

[10] John Grant, "Experiments on Portland Cement," *Proc. Inst. Civil Eng.*, *25* (1865), 66-158.

The ancients believed that the changes attending the heating of limestone consisted mainly in the discharge of the air and water contained in it, and that when the lime was again placed in water it recombined with the air and water by which process it again became firm. Even up to the nineteenth century this conception had been modified but little.

In a memoire published by the Academy of Sciences of The Hague in 1832, Fuchs[11] maintained that the only role of calcination was the dissociation of the clay and limestone whereby the silica of the clay was brought into a condition such that it could combine with the lime when the product should be gauged with water.

Chemical Theories

Rivot and Chatonney[12] in 1836 suggested for the first time that the hydraulicity of cement might be due to the formation of "a silicate of lime, an aluminate of lime and a silico-aluminate of lime forming hydrated salts under the action of water."

Pettenkoffer[13] (1849) supported the theory of Fuchs, and Feichtinger[14] speculated further:

> After the calcination we have an amorphous mixture of the silica and much free lime. To effect the hardening in water a triple chemical action enters into play. First, there is a fixation of water by all the constituents. Following this, the combination of silica with lime. It is this which constitutes hardening. Finally the free hydrated lime is carbonated by the carbon dioxide of the air.

Heldt[15] in 1853 claimed the formation of an active silicate and of an inert aluminate. In 1863 Zulkowsky[16] first referred to *hydraulite*, which he regarded as a "basic puzzolanic which, when mixed with free lime, forms cement."

Fremy[17] in 1866 published a paper which stands prominently among those of this period. He claims to have prepared a variety of calcium silicates, calcium aluminates, and double silicates of lime and alumina. He reported the silicates to be without hydraulic action, while the aluminates he found on gauging with water to "solidify almost instantly and produce hydrates which acquire in water a considerable hardness." Furthermore, when these aluminates were mixed with large amounts of sand, he obtained mortar which "acquired the hardness and solidity of the best stone." Fremy believed, as a result of these experiments, that portland cement contained calcium aluminates and silicates, a double lime alumina silicate and free lime. Hydration then consisted in the hydration of the aluminate, and the reaction of the free hydrated lime with the silicates and double silicates.

In 1876 Knapp[18] claimed that the solidification was due to a combination of both chemical and physical forces. Landrin[18a] believed in the presence of a special product, probably similar to the hydraulite of Zulkowsky, which he named *puzzo-portland*.

Summary

This brings us to the period of Henri le Chatelier.[19] The views held by investigators at this time were, for the most part, the product of speculation and those experiences of operative technique which gradually and inevitably bring out data and of which the inquisitive mind demands some explanation. There had been formulated very little research designed to solve definitely the problem of chemical constitution of clinker. The investigations attempted had been confined for the most part to engineering problems or manufacture and the chemical and engineering problems of setting and hardening. The theories on constitution were consequently those of speculation and not of intelligently directed experimentation. In general, these theories were of three types: (1) that clinker consists of a mixture of anhydrous lime and silica which combine when brought in contact with water; (2) that some of the lime and silica are caused to combine by the burning process forming a mono- or possibly a di-calcium silicate, and leaving an excess of free lime; and (3) that clinker consists of hydraulic calcium aluminate, silicates and free lime which combine during the hardening process.

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[11] Fuchs, Memoire, Acad. Sci., Hague, 1832.

[12] Rivot and Chatonney, "General Considerations on the Materials Employed in Construction," *Compt. rend., 153* (1856), 302; 785.

[13] Pettenkoffer, 1849. *Cf.* E. Leduc, *Op. cit.*

[14] Feichtinger, 1849. *Cf.* E. Leduc, *Op. cit.*

[15] Heldt, *J. Prakt. Chem., 94* (1853), 129; 202.

[16] Zulkowsky, 1863. *Cf.* E. Leduc, *Op. cit.*

[17] Fremy, "Researches on Hydraulic Cements," *Ann. chem. phys., 7* (1866), 73.

[18] Knapp, 1876. *Cf.* E. Leduc. *Op. cit.*

[18a] M. Landrin, *Compt. rend., 96* (1885), 156; 1229; *98* (1887), 1053.

[19] Henri Le Chatelier, "Experimental Researches on the Constitution of Cements and the Theory of Setting." *Compt. rend., 94* (1882), 13; *J. Soc. Chem. Ind., 1* (1882), 151. "Experimental Researches on the Constitution of Hydraulic Mortars," translated by J. L. Mack, New York, 1905.

The Concretor Goes to School

When the Experienced Concretor Found That He Could Go to School Again and Learn All About the Application of Water-Cement Ratio to Job Control He Quickly Took Advantage of the Opportunity—How Many Learned About the New Ways of Getting Better Concrete

The utter simplicity of the newer methods of the control of concrete quality has been well demonstrated to many engineers, contractors and architects in a series of schools that have been held throughout the country during the past two years. In fact, so successful have been these short courses that they are to be continued next fall for the benefit of those who were not able to take advantage of them during the past two seasons. These schools, having for their purpose the teaching of the application of the Abrams Theory, have consisted of short courses running from three to eight sessions, scheduled in such a way as to make it easy for the busy concretor to utilize his spare time for the purpose. As a result of these schools, attended as they were by many a man who has already grown grey in the construction industry and rated as a leader in his profession, there is an ever-increasing army of experienced concretors who are now able to apply the latest scientific findings to their own work.

The courses achieved a great expansion in but a short time. They began some three years ago as a short course for field men of the Portland Cement Association, whereby twenty men a year were permitted to visit the Structural Materials Research Laboratory and find out just what it was that Dr. Abrams had been advocating. It was not long, however, before outside engineers heard about the interesting work and began to demand the same opportunity. Since it was out of the question to bring hundreds of engineers to the laboratory—engineers living in all parts of the country and busy on millions of dollars worth of concrete construction that could not wait while they went to school—it was finally decided to bring the laboratory to the engineers.

Starting the Schools

Members of the laboratory staff were accordingly assigned to the work and were sent out to the various parts of the country where there was a demand for the information. Wherever a sufficient number of concretors desired such a school, there a school was held. The first was in Birmingham, then came schools in other southern cities, and before long they were being held throughout the country. For the most part the schools were held under the auspices of one of the larger universities, while a few were sponsored by local engineering societies, and several were conducted by the Portland Cement Association. In every case a representative of the Structural Materials Research Laboratory was present or even in charge, and some prominent local contractor or engineer who had already become acquainted with the Abrams Theory was prevailed upon to give at least one lecture.

Each course consisted of a series of meetings at which the practical application of the Abrams Theory was worked out in detail. The theory of proportioning was stripped of all technical discussion and presented by the case method in a very understandable manner. The "students" were shown how to apply the principle under discussion in order to obtain more uniform concrete on their own work.

Although not all courses contained a total of eight sessions, yet the shorter courses were so planned that they really imparted as much information as the longer ones, in a more condensed form. The eight-session course, however, proved of most value. The one given at the Carnegie Institute of Technology, at Pittsburgh, Pa., last March, will be of interest. The sessions were held on Monday, Tuesday, Thursday and Friday evenings for two weeks, and ran from 7:30 to 10:30 p. m., beginning March 22.

Fundamental Factors

The first session was devoted to an introductory talk on quality concrete and the purpose of the school. Then the program was outlined and the method of attack was discussed, followed by a talk on the fundamental factors of good concrete, the water-ratio theory, and the method of the design of concrete mixtures according to that theory. Then came a demonstration of standard field methods for making tests of aggregate, determinations of unit weight, moisture content and bulking. The next step was a little preliminary work in the design of a concrete mixture, and problems in unit weight of aggregates and the bulking effect of moisture in sand.

The first hour of the second session was given over to a lecture on the properties of aggregates and specifications and tests, together with a demonstration of sampling methods and the making of a sieve analysis of aggregates. The balance of the session was devoted to related problems in the design of concrete mixes, shrinkage, fineness modulus, and the maximum permissible size of aggregate. Then a concrete mix of a given strength was designed, using local aggregates.

Computing a Mix

The third session began with further computations on the design of concrete of a given strength, providing for all details of the batch. This batch was then actually made up and a set of test cylinders were then molded for test at seven days. This was taken as an occasion for a demonstration of standard methods for mixing and molding concrete test specimens and of the standard slump tests for consistency.

On the fourth evening the first item on the program was an investigation of a field job under way, and this was followed by a talk on the water-ratio specification for quality of concrete and proportioning. Then came some work on the trial or water-ratio method of proportioning concrete, together with laboratory work in proportioning and molding test cylinders by the trial method.

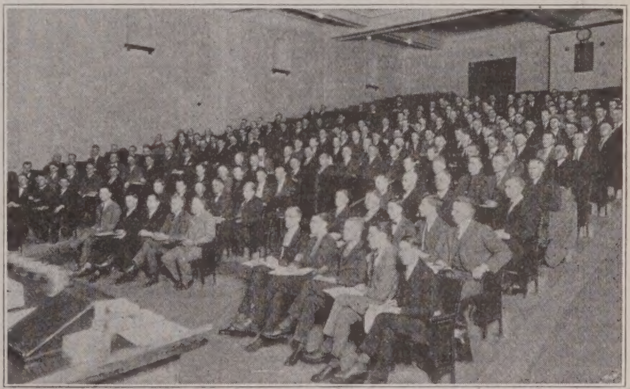
The fifth session began with a description of concrete literature available to engineers, and a problem in the design of a concrete mixture, using field sieves and volume measurements, with cost comparisons of various mixes. Then those attending the meeting were told the correct way to use Bulletin 1 of the Structural Materials Research Laboratory in the design of mixes. The engineer in charge then carried on a demonstration of the colorimetric test for organic impurities in sands and the absorption test for coarse aggregates.

The sixth session began with a lecture on the inspection of concrete, and an exposition of the use of the Joint Committee Table. Then several problems in the design of concrete mixes, cement factor and slump were worked out and demonstrations of clay and silt tests for aggregate, the decantation test, and the sedimentation test, were made.

Visit the Laboratory

At the seventh session the "students" visited the local laboratory, where they were given a further insight on testing methods and were given the opportunity to witness the tests of the cylinders cast at the third and fourth sessions, and then were asked to analyze the results of the tests in light of the mixes designed for. Then came a dis-

Three engineers from the laboratory conducting the class at the University of Minnesota. Note the equipment for demonstrations laid out on the lecture table



Another view of the same group of contractors, engineers, architects and other concretors listening to a lesson on the making of better concrete. No curiosity seekers here!

cussion of the effects on the strength of concrete of age, curing conditions, condition of specimen, shape of specimen and so forth. Then came a lecture on field tests of concrete and on field control, and this was followed by a brief review of the problems and of the entire course. The eighth session was devoted to a written review of the course, and a conference for engineers who did not wish to write out the review, but who were seeking further information about the subject matter of the course.

This course was successful. In fact there were over 700 men enrolled in the school, and the average attendance at the different sessions was 467. Those attending the school included engineers, contractors, architects, inspectors, construction superintendents and foremen, salesmen of concrete materials and equipment, and others interested in concrete construction.

Other schools held throughout the country showed a like record. In many cases men came for hundreds of miles to attend the courses, and expressed themselves as being quite satisfied with what they had learned, and showed a desire to apply the new things that they had learned to their own work.

Everything Simple

It is interesting to note, in connection with the courses, that the calculations and methods utilized are of the very simplest type. Three years' experience with that method of control, on hundreds of structures, have naturally reduced things to the lowest common denominator. Everything is explained in the simplest way, and the easiest and quickest methods of application are the ones taught. It is this simplicity that appeals to the man who is used to more archaic methods of job control, since his acceptance of the more refined methods would be based upon the ease with which they could be applied on the job.

ATTENDANCE AT SHORT COURSES IN DESIGN AND CONTROL OF CONCRETE MIXTURES

Place	Sponsor	Total Enrolled	Average	Dates
Birmingham, Ala.		170	73	May, 1925
Atlanta, Ga.	Georgia Tech.	160	78	June, 1925
Montgomery, Ala.		45	25	June, 1925
New Orleans, La.	Tulane Univ.	260	146	Oct., 1925
Nashville, Tenn.	Vanderbilt Univ.	148	72	Oct., 1925
Ada, O.	Ohio Northern Univ.	72	66	Dec., 1925
Boston, Mass.	Mass. Inst. of Tech.	184	145	Dec., 1925
Hutchinson, Kans. (Nov.)		78	33	Nov., 1925
Hutchinson, Kans. (March)		33	25	March, 1926
Tuscaloosa, Ala.	Univ. of Alabama	84	43	Nov., 1925
St. Joseph, Mo.		97	38	Dec., 1925
Paducah, Ky.		20	18	Jan., 1926
Topeka, Kans. (Jan.)		198	105	Jan., 1926
Topeka, Kans. (March)		59	45	March, 1926
Kansas City, Mo.		353	175	Jan., 1926
Minneapolis, Minn.	Univ. of Minn.	406	211	Jan., 1926
Hanover, N. H.	Dartmouth Univ.	21	20	Jan., 1926
Indianapolis, Ind.	Purdue Univ., Extension Dept.	180	100	Feb., 1926
Owensboro, Ky.		35	30	Feb., 1926
Detroit, Mich.	Detroit Eng. Society	274	182	Feb., 1926
Lincoln, Nebr.		200	98	April, 1926
Omaha, Nebr.		244	115	Feb., 1926
Iowa City, Ia.	Iowa City Eng. Soc.	117	70	March, 1926
Pittsburgh, Pa.	Carnegie Institute of Technology	702	467	March, 1926
New York, N. Y.		800	573	April, 1926
Philadelphia, Pa.	Drexel Institute	500	356	April, 1926
Albany, N. Y.	Albany Eng. Society	125	96	April, 1926
Providence, R. I.	Brown Univ.	100	80	March, 1926
College Station, Texas	Texas State Univ.	30	30	March, 1926
Mobile, Ala.		34	31	March, 1926
Chanute, Kans.		51	40	March, 1926
Salina, Kans.		41	35	March, 1926
Syracuse, N. Y.	Technical Club of Syracuse	174	160	April, 1926
Cleveland, O.	Cleveland Eng. Soc.	325	250	April. 1926
Morgantown, W. Va.		77	60	April, 1926
Buffalo, N. Y.	Engineering Society of Buffalo	200	158	May, 1926
Total		6597	4249	

Here is a list of the schools that have already been held, together with the organization, if any, holding the school, the total number enrolled for the work, the average attendance at a meeting, and the time the meeting was held

Since the courses are of a practical nature there is really no end to the questions that are discussed as time allows. The effect of damp curing, time of mixing, admixtures, methods of handling, and many other interesting subjects are brought up by the "students" and discussed by every one present. The importance of sticking to A. S. T. M. specifications and methods is insisted upon at every opportunity. Everything that will help the visitors make better concrete is touched upon as fully as possible.

It is of interest here to state that these schools are aiding greatly in the dissemination of better nomenclature. For interest, no such thing as "fineness modulus" is now spoken of. The new term for that measure of grading is "Grading Factor." Then there are the other two important factors used in aggregate computations—Shrinkage Factor and Bulking Factor.

For the Experienced Man

The theory of these courses is that the development of the art of making good concrete is so rapid that few men can hope to keep up with the times unless they do a lot of reading or unless they devote a little time to such a school. Since the latter plan appears to take up the least time and affords opportunity for necessary discussion the schools were started. So successful have they been that the demands have been such that the laboratory cannot hope to keep up with the requirements. Several universities have signified a desire to assume the full burden themselves and make the schools an annual affair in their districts. Affording an opportunity for the older men of the profession to learn the things that were unknown when they went to school, these schools are proving very popular, and will be continued during the coming year.

Texts used include Bulletin 1 of the Structural Materials Research Laboratory, and the Portland Cement Association booklets, "Instructions to Field Men for Making Concrete," "Standard Specifications and Tests for Concrete and Concrete Aggregates," "Predetermining Concrete Strength on Park Bridges," and "Concrete Data for Engineers and Architects."

Block Makers Consolidate

The consolidation plan of the National Concrete Products Corporation was declared operative on May 31. Announcement was made by Charles R. Flint and George L. Benbow acting for Flint & Co., Inc., and Rufus Waples & Co., of Philadelphia. The Girard Trust Company of Philadelphia will act as trustees. Transfers of ownership will be based on appraisals of plants and inventories of May 31.

The consolidation will manufacture cinder block under the Warner patents, which were also purchased. The cinder block industry was developed under Straub & Co. patents and within eight years has attained a production capacity of 50,000,000 block.

A. G. C. Mixer Bureau Holds Meeting in Chicago

Important action was taken by the Mixer Manufacturers Bureau of the Associated General Contractors of America at its recent meeting in Chicago.

The question of substitution of a 10-E paver for the present 7-E machine was again given consideration, but no decisive action was taken. The problem of the proposed rating was assigned to the technical committee with instructions that a report be returned to the Bureau at its next meeting.

An Enormous Triple Barrel Concrete Sewer

Nearly 15,000 Feet of Storm Water Sewer in Brooklyn—Has 99,000 Yards of Concrete Mixed in Caterpillar Traction Pavers—Reinforced with 6,300 Tons of Steel Chuted to Place in Wood and Collapsible Steel Forms

By FRANK W. SKINNER

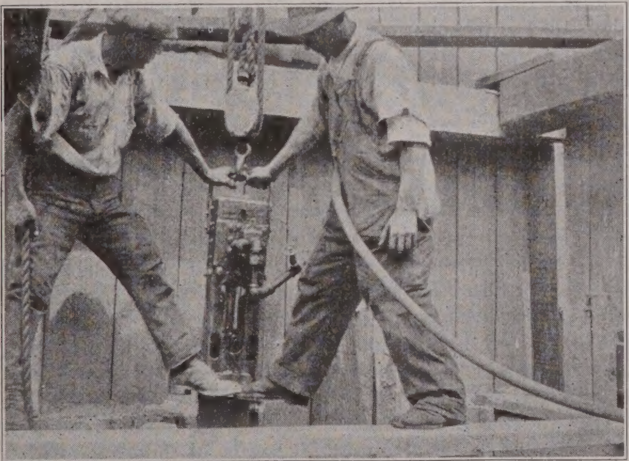
Storm water from 3,500 acres of residential area in Brooklyn will be discharged to Jamaica Bay through one of the largest sewers in the world, 14,800 linear feet of which is now being constructed under the direction of Chief Engineer A. J. Griffin, Consulting Engineer Phillip P. Farley, and Superintendent James J. Browne.

This sewer, with several right angle bends, extends from Foster Avenue, where it commences with a single-barrel cross-section, to its terminus at a receiving chamber that has an open channel outlet to the bay. At the lower end the sewer is 47 feet wide and 13 feet deep, with a roof 22 inches thick and sidewalls 16 inches thick. It is rectangular in cross-section and is there divided into three channels by means of two vertical intermediate reinforced partitions. The concave invert is paved with vitrified brick and all of the concrete is thoroughly reinforced with steel bars. The cross-section diminishes away from the outlet and includes several sizes of triple and double-barrel sewer and single-barrel sewer with minimum outside dimensions of 14 feet 10 inches in width and 12 feet 4 inches in height. There are required about 446,000 bags of portland cement, 47,000 yards of sand derived from the excavation and 93,000 yards of 1½-inch broken stone, besides 5,500 tons of Belgian and 800 tons of domestic reinforcement steel.

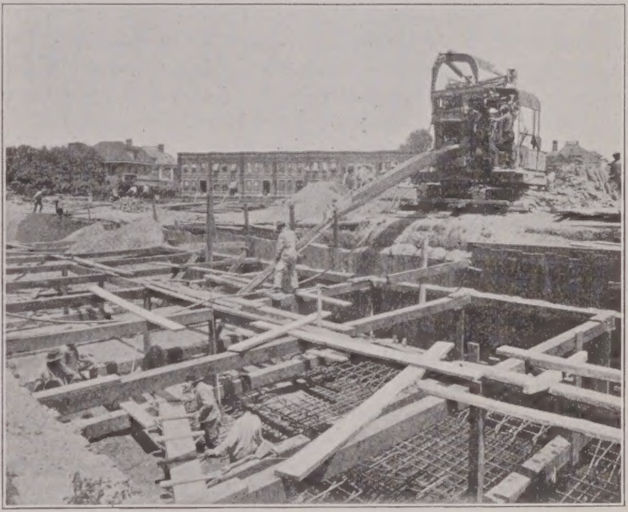
Built in Open Trench

The sewer is built entirely in open trench, having a maximum width of 52 feet and depth of 35 feet, which was excavated for the most part between trench lines, cut through the pavement by two pneumatic pavement busters, using air furnished by two portable compressors, all supplied by the Chicago Pneumatic Tool Company.

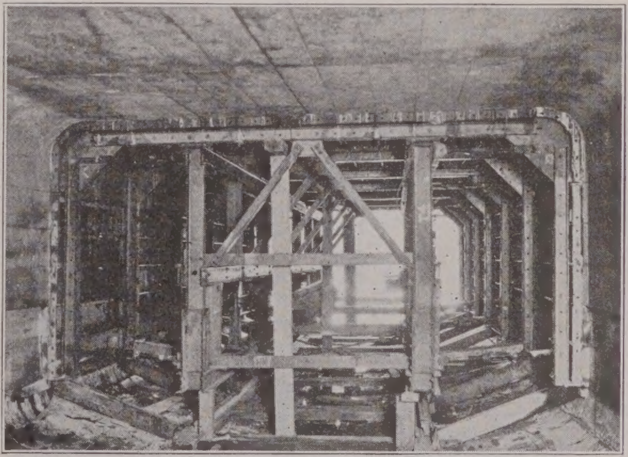
The trench was excavated through earth and top soil from 8 to 12 feet and then through sharp clean sand to a maximum depth of 35 feet, involving a total amount of nearly 500,000 cubic yards which, according to the conditions prevailing in different parts of the work, was handled by several methods, using a large equipment of standard power machinery that included 3¾-yard steam shovels that removed the first cut down to a depth of 14 feet and loaded into 5-ton Corbitt trucks at street level at an average rate of about 600 yards each per 8-hour shift. In other places the top soil was excavated down to the surface of the sand stratum by four ¾-yard dragline buckets operated by gasoline-driven Link-Belt all-purpose crawler cranes or by several Blaw-Knox dreadnaught ex-



Driving wooden sheeting with air hammer.



Mixing and placing concrete with a paving mixer



Steel form supported on adjustable steel traveler in three-barrel section of sewer cavating buckets and other types of clamshell buckets handled by the crawler cranes and depositing the material, like that delivered by the dragline buckets, in spoil banks on one or both sides of the street.

The Link-Belt cranes, with 50- and 60-foot booms were almost universal in their service both for excavation and for handling the heavy construction equipment. They were of the standard heavy duty rapid movement type with improved details with a record of excavating materials (on another contract) at a cost of about 5 cents per cubic yard in large quantities under favorable circumstances.

Vertical Sheeting

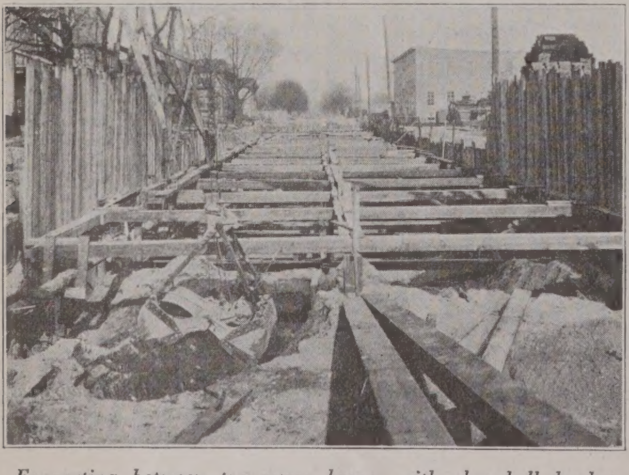
The trench was sheeted everywhere with one or two tiers of 2- and 3-inch vertical planks, 16 to 18 feet long that were driven by double-action steam hammers operated by air pressure, and all of them handled by the cranes or suspended from light movable tripods.

In the deepest part of the trench the sheeting was braced with five tiers of transverse struts, which in all cases were placed at least 10 feet apart to permit the operation of excavating buckets which worked to sub-grade and delivered the sand either to storage heaps for backfill and for use in concrete aggregate or to trucks that removed it for commercial and building purposes. Earth and sand were handled by a fleet of about 30 5-ton trucks.

Near the outfall the trench was excavated considerably below ground water level, and large quantities of water were drained into sumps from which it was removed by four 8-inch electrically driven centrifugal pumps. In other cases the water intercepted from branch sewers was impounded at manholes by sandbag dams and removed by two 6-inch and one 10-inch gasoline pumps. Where sumps were not provided or were frequently shifted the water was conveniently handled by 3-inch portable pump and gasoline engine outfits.

Aggregates

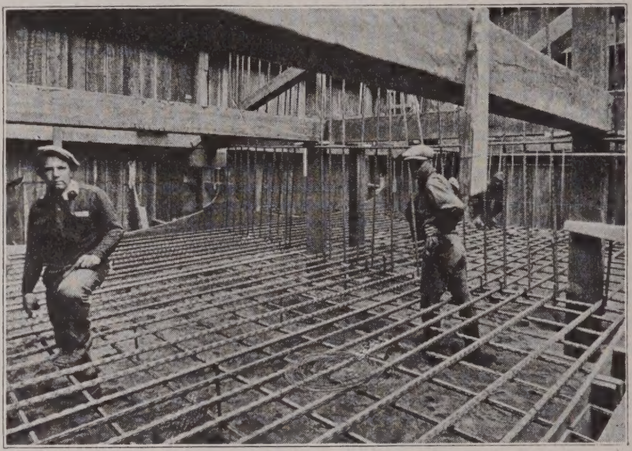
The 99,000 yards of concrete was made with 446,000 bags of portland cement, 47,000 yards of sand excavated from the trench which was clean, sharp and satisfactory for use without washing or screening, and 93,000 yards of 1½-inch broken stone, provided by the B. Turecamo Construction Company, and delivered from the Tompkins Cove quarries in barges that were unloaded by two ¾-yard steam shovels dumping into a fleet of twenty 5-ton Pierce Arrow trucks that easily climbed to the top of a 25-foot storage pile that itself formed a ramp carefully graded and surfaced with stone equivalent to macadamizing that enabled the trucks to dump on top of the pile and thus build it out indefinitely. The same trucks delivered from the storage pile to the street piles near or alongside the sewer trench, sometimes transporting as much as 1000 yards per day.



Excavating between transverse braces with clamshell bucket

The aggregate was delivered to six concrete mixers by six 1-yard dump trucks and by 12 truck chassis, on which bodies from standard mine cars were mounted to dump longitudinally or transversely. On one section of the sewer the trucks were loaded by four and on the other section by three measuring wagon loaders thus saving a considerable amount of labor, insuring exact quantities and expediting the service.

The cement, furnished daily as required, was delivered by trucks to platforms about 6 feet wide and 20 feet long, that were elevated a foot above the street surface and were located at the curb near the concrete mixers, being shifted with them from time to time as the work progressed. For one day's supply a mixer required about 900 bags of cement, which were piled on the platform and thoroughly protected by tarpaulins. The cement was delivered from the platforms to the mixing machines by wheelbarrows. At each platform there were required one checker and three laborers, who also built and shifted the platforms.



Assembling reinforcement for invert and side walls

The reinforcement steel in bars up to 40 feet long was cut to length by the contractor with oxy-acetylene torches. The steel for one section was stored and bent at the dock, where it was received, and for the other section was stored at the contractor's yard and bent on a special power table with hydraulic plungers that were operated to simultaneously make eight sharp bends of a 1-inch bar in 30 seconds. The long bars were delivered where required alongside the trench by a trailer with a very long wooden platform supported on a pair of heavy channel beams balanced on two wheels and hauled by a tractor.

Placing Concrete

For Section B concrete was placed in wooden forms made at the contractor's shop and thoroughly cleaned, inspected, and if necessary, repaired, after each paving. The invert concrete was laid on the carefully trimmed subgrade between transverse wooden bulkheads, 40 feet apart, and was well tamped around the reinforcement bars suspended from the lower tier of trench cross-braces. At the intersection of the sloping sides of the invert by the sidewalls there was placed a 90-degree cove form, made with longitudinal lagging.

A 40-foot section of the invert, of the 180-inch single-barrel sewer required about 30 yards of concrete, which was placed by four men, exclusive of the mixer gang, in about four hours. After this concrete was 24 hours old the lower tier of the trench bracing was removed and a gang of four bricklayers and fifty laborers paved the invert with vitrified brick furnished by the A. S. Reid Brick Co., Inc. A strip adjacent to the side-wall was paved with special tile.

The wall forms were made with panels 20 feet long and 6 feet 2¼-inches high, having 1½-inch finished square edge horizontal boards nailed to 4x6-inch verticals 30 inches apart. Originally they were supported from a rigidly braced wooden framework of a 6-wheel car running on the broad gauge invert track. They were adjustably connected to the car by turnbuckle rods that enabled them to be quickly set to the exact position and alignment and easily stripped and shifted without removing from the car. They worked satisfactorily until after a thin film of cement had dried on the surface of the forms, when it was found easier to detach them entirely from the car and clean them in a horizontal position so that subsequently the cars were discontinued. The roof forms 8 feet long were mounted with jackscrew supports on 4-wheel broad gauge trucks and after the concrete was 72 hours old were stripped by slacking off the jackscrews and the connections of the curved longitudinal sections connected the roof and wall concrete.

Side Walls

The side-walls were concreted in sections twice as long as those of the invert, 80 linear feet of both walls being concreted in about four hours by a 5-man gang that subsequently stripped the panels, laid them flat on the sewer invert, cleaned them, shifted and re-erected them in about two hours. In the double and triple barrel sewers the vertical partition walls were concreted in the same manner as the side-walls. The reinforcement for walls and roof was carefully wired in position and as in the case of the side-walls, the concrete was spouted directly to position and thoroughly tamped around the steel by a small force.

At the commencement of the work on the double and triple-barrel sewers in Section A there were installed 120 linear feet of three-barrel Blaw-Knox steel roof and wall forms mounted on adjustable carriages and provided with invert tracks 5 feet 2½-inch gauge. This equipment was found very satisfactory and one 40-foot section of it was stripped, cleaned and advanced to the next position and adjusted ready for use by a six-man gang in about two hours.

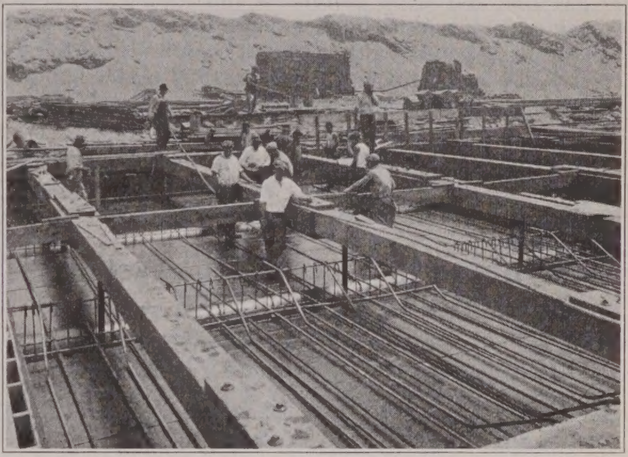
After the work was commenced it was found difficult to maintain the concreting at the same speed as the excavation and bracing and supplementary wooden forms were built in order to save the longer time that would have been required to order, manufacture and receive additional steel forms. Four complete sets of wooden forms mounted on adjustable travelers were provided and the concreting operations with them were substantially the same as in Section B. A longer time was, however, required cleaning, moving and re-setting the wooden forms than for the steel ones.

Paving Mixer Used

Each batch of concrete was made with six bags of portland cement, ½ yard of sand and 9/10 of a yard of stone supplied by the B. Turecamo Construction Company. It was mixed in caterpillar traction concrete paving machines selected on account of their independent locomotive construction that enabled them to follow along on the top of the bank adjacent to the work and deliver, through chutes to any portion of the forms without re-handling the concrete. They were also satisfactory because of the ease with which the aggregate was loaded to them direct from the trucks that delivered it from adjacent storage piles.

The wood forms for the roof slab of the 180-inch sewer are made in 8-foot sections and a transverse width equal to the clear distance between the vertical sidewalks. The 8x9-foot horizontal surface of the form is made of 2x12-inch dressed boards nailed on top of two pairs of 2x10-inch transverse beams supported on three longitudinal beams 2 feet apart that are carried on the caps of two 4x4-inch adjustable vertical posts 4 feet apart on the center line of the sewer. The 90-degree fillet pieces with a 12-inch radius are hinged to the 8-foot longitudinal edges of the form platform and can be kept in place tangent to the horizontal and vertical surfaces by inclined braces. The vertical posts fit between piers of transverse guide frames and their lower ends are supported on screw jacks on the platform of a 4-wheel truck running on a 5½-foot gauge invert track.

When in position for concreting the overhanging ends of the transverse beams are supported on shores with bottom wedges. To strip the forms the wedges are slacked, shores removed, fillets revolved downward and the jacks screwed down, making clearance everywhere with the finished work and allowing the car and form to be advanced, form cleaned and reset for the next section of roof slab, an operation that can be performed with minimum labor and time. Similar roof forms are provided for the other sizes of sewer.



Reinforcement for roof slab. Note the long bent "truss" rods Cross-section of triple-barrel sewer

On Section A there were installed one T. L. Smith, one Koehring and one Rex paver, and on Section B one Ransome and two Oshkosh pavers, all of which gave efficient service and afforded satisfactory demonstrations of efficiency, economy and convenience, thus proving the value of this type of machine for rapid, heavy form work.

The trench was back-filled by clamshell buckets operated by the locomotive cranes and the surface of the ground was dressed by a road-finishing machine.

Placing Sheet Piles

The sheet piles retaining the vertical sandy sides of the deep trenches were driven at a rate of about 1,000 square feet per day by each of the double action steam hammers operated by compressed air, of which there were installed and exclusively used on the deepest trench, ten No. 6 and No. 8 Union Iron Works steam hammers. On a portion of the line where special precautions were taken to prevent any displacement of the soil in the street the sheeting will be allowed to remain permanently in position, elsewhere it was pulled by tackles operated by the locomotive cranes. The hammers worked well when partly submerged and were adapted for operation in harness to pull refractory piles by reverse driving, but this service was not here required. The 195-pound hammers struck 475 400-pound blows per minute, with a consumption of only 50 cubic feet of air at 100 pounds receiver pressure.

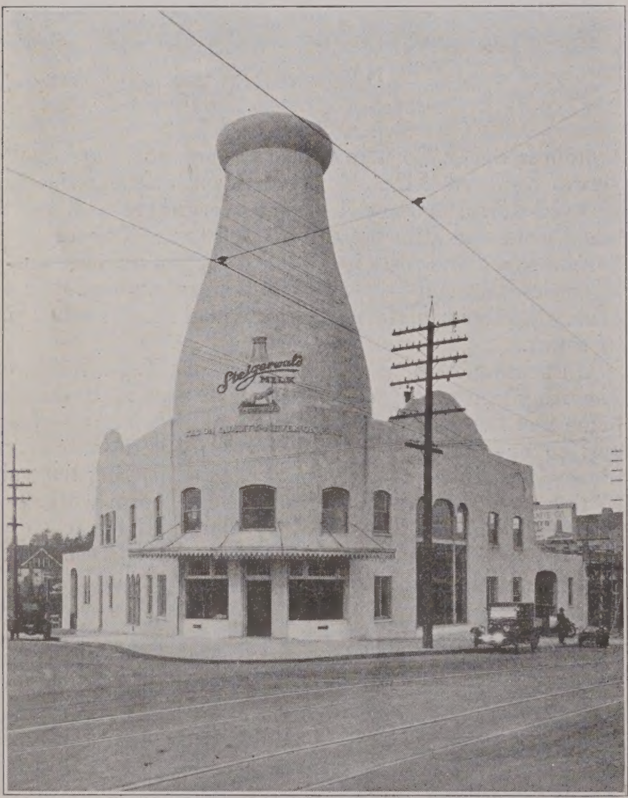
Besides the equipment already enumerated, there were installed for general service on this contract three tractors, one of which operated the machinery in a repair shop, two 6-inch and one 10-inch gasoline pumps and two 3-inch portable pumping units driven by gasoline engines and shifted from place to place to deliver the water from an an old sewer in the line of the new one to lateral sewer lines in transverse streets.

On each division the contractor established a storage yard and repair shop equipped with hand and power tools and with materials and supplies necessary for maintenance and renewal work, and for simple construction. He also provided storage tanks from which, during the first seven months of the work there was distributed to the motor trucks and other machinery, about 70,000 gallons of gasoline and 3,500 gallons of lubricating oil, thus securing prompt and economical supplies.

The construction, although not required by the contract to be completed until August, 1926, was commenced April 15, 1925, and was 85 per cent completed February 1, 1926. It is being executed by the Montrose Construction Company, J. B. Carlin, president, and S. Kent, chief engineer; D. W. Armstrong is the general superintendent, and Louis B. Wilcox is the superintendent of Section B.

Unique Concrete "Milk Bottle" Building at Portland, Ore.

Permanence in advertising is the motto of the Steigerwald Dairy Company of Portland, Ore. And in the creation of this permanent advertisement, concrete was the material used.



The Steigerwald Dairy Company's milk bottle building stands at the corner of Thirty-seventh and Sandy Boulevard, in a prominent location in Portland's East Side. The bottle is 75 feet high, 27½ feet across at the bottom and approximately 5 feet in diameter at the cap.

The main part of the building has monolithic concrete walls. The portion of the bottle within the building has concrete walls up to 8 inches thick. Above, the bottle is stucco on a framework of wood. One interesting feature of the structure is that the usual unsightly water tanks that grace a building are housed within the bottle. And around the tanks a circular stairway has been provided so that sightseers may climb to the cap of the bottle and obtain a beautiful view of the mountains and of a large portion of the East Side.

Efficient arrangement of the various departments also marks the building. In the basement, in addition to the heating apparatus, are the refrigerating plant, storeroom and a kitchen for a lunchroom which is located on the main floor. The pasteurizing and bottling machinery and a shipping room are on the first floor. Offices, a laboratory and a lecture room which is to be used in the interests of "use more milk" are found on the second floor.

Colored cement stucco was utilized to reproduce the familiar "cream line" on the milk bottle.

Showing the Plasterer How It Is Done

Appreciating the pronounced interest that is being taken by the building public in general throughout the country in the creation of textural and color effects in stucco work the Portland Cement Association has taken the initiative in providing nation-wide demonstrations of its application.

The greatest drawback in furthering the use of such real decoration in exterior surfacing, has been the inability to get a workman who knows how to make textures and use colors harmoniously. The material, portland cement stucco, adequately meets all requirements for a satisfactory surfacing in which colors and textures may be incorporated to beautify the building. With the interest now manifested by architects and owners, it is imperative that the craftsman be trained accordingly.

E. J. Kennedy, of Los Angeles, Calif., "where architecture and color blend in perfect harmony with the individual tastes of every builder," is the craftsman-artist chosen to conduct demonstrations throughout the country before meetings of journeymen plasterers, architects and all others interested in learning more about plastic texturing.

He has for many years been actively engaged in the business of applying stucco, is an outstanding figure in the plastering world and is recognized as an authority on application and textures.

He has the viewpoint of the craftsman who realizes the artistic possibilities inherent in the colored plastic in which he works, and what he is doing is a striking illustraton of what other plasterers can do if they vision their profession in the same broad way.

The earliest users of exterior stucco employed color lavishly yet builders in following centuries abandoned or lost this art and the legends that there were no colors which would permanently stand with lime in stucco gained strength until it became a byword in the plastering craft.

Few attempts were made to overcome the limitations set by the use of colored aggregates until a few years ago when experiments in colored stucco carried on in California proved that there are many satisfactory coloring materials for stucco. The experimental work grew in magnitude, the local interest increased from state-wide to country-wide scope until it is now realized that color in stucco has practically been recreated.

To date the intense interest shown by those who have witnessed Mr. Kennedy "in action" has presaged a worthy appreciation and a widespread adaption of colored portland cement stucco for all types of buildings. It indicates that the owner, the architect, the builder and the craftsman-plasterer are fully alive to their duty to carry this development to its proper standing in construction.

Use of Exposed Concrete Block in the East

The use of the exposed hollow concrete building unit has been seriously retarded in the East as a whole by the use of rock face block. Where attempts have been made to market a face unit these have generally been of such unfortunate combinations of aggregates or using such freak aggregates that they made no appeal whatever to the discriminating architect or builder.

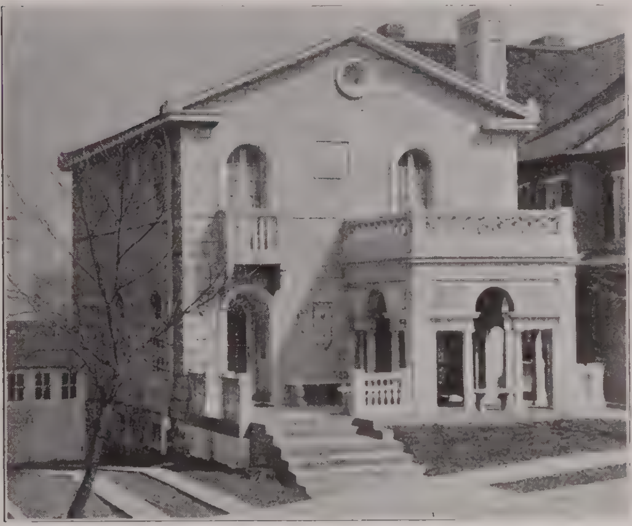


Fig. 1. A pleasing appearance attained with buff-colored block and concrete trim stone.

At the same time it was felt by observers that the concrete block need not always be covered with stucco or used to back up a brick veneer and it is gratifying to note that there are a number of very interesting architectural examples in the East now where concrete block construction stands on its own merits.

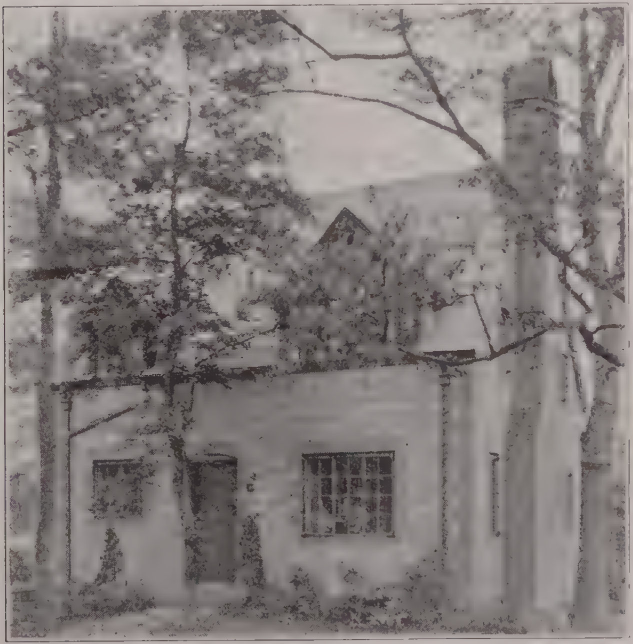


Fig. 3. Ordinary concrete block were used to build this pleasing little house at Larchmont, N. Y.

One of the oldest jobs of this type is the Boyd residence at Yonkers shown in Figure 1. The block are of a warm buff color. The ornamentation is cast stone and some color has been introduced in the little fountain and over the arches on the porch. A very large job is the Weekes house at Islip, Long Island, Grosvenor Atterbury, New York, architect, which was described in this magazine several years ago. For the benefit of the readers who did not see the original article a photo of the circular entrance tower is given in Figure 2. The block on this job were made of concrete in three varying shades, cream, buff and gray, and before the block set up the surface was stippled to give the texture shown in the photo.

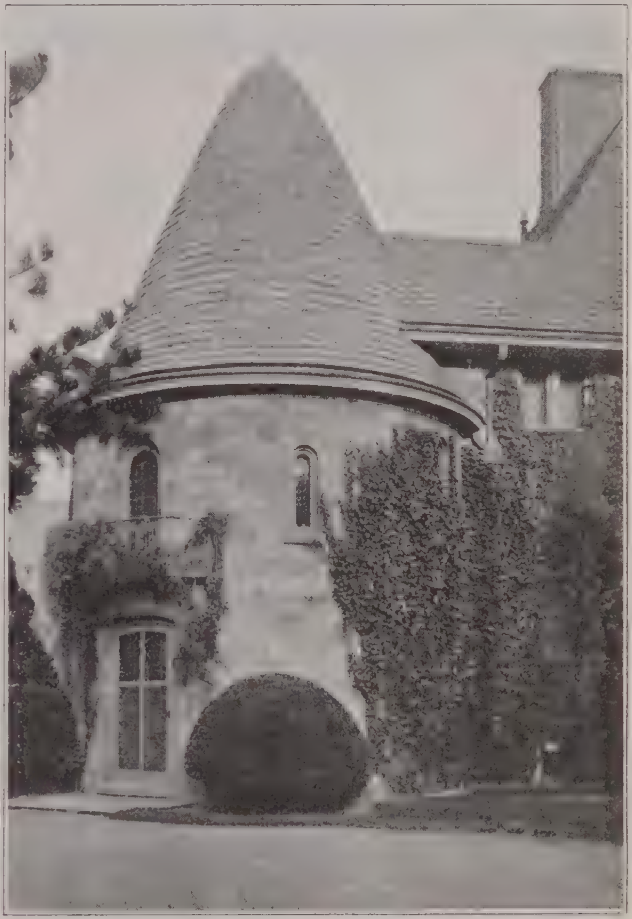


Fig. 2. Circular tower of the Weekes house at Islip, Long Island. Grosvenor Atterbury, architect.

A little house in Larchmont is shown in Figure 3. Here the builder has used the ordinary "common or garden variety" of concrete block laid up the same as stone would be laid and depending entirely for ornamentation on brick sills, lintels and quoins. Set in the midst of a little group of trees, this little house is an exceptionally charming structure and it well illustrates the possibilities inherent in the proper use of the ordinary concrete block.

Figure 4 is a photo of one of a pair of houses at Orienta Point, New Rochelle, N. Y., E. D. Parmelee, New Rochelle, architect. Here again a very interesting use has been made of the block. A Spanish style of architecture has been used and the block have been laid with flush joints

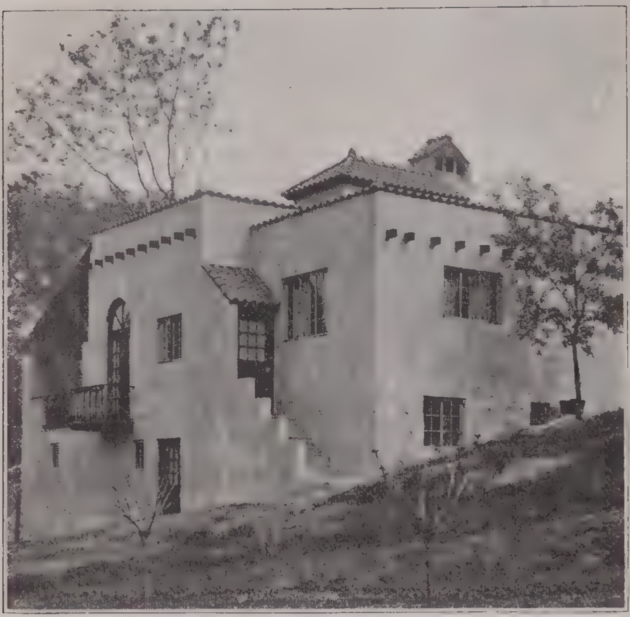


Fig. 4. Adapting the use of concrete block to the Spanish type of house.

and given the coat of whitewash usually found on masonry structures in Latin countries. Slight irregularities in laying give a texture to the wall which is very attractive. This same idea has since been employed in a $300,000 country house at East Norwich, N. Y., Delano & Aldrich, New York, architects.

Another interesting application of the idea of exposed block is shown in Figure 5, which represents a row of houses in upper Derby Township, a suburb of Philadelphia, where the builder, John H. McClatchey of Philadelphia, has used the block with a raised squared white mortar joint similar in effect to the treatment ordinarily applied to a great deal of stone masonry construction in Eastern Pennsylvania. The architectural appearance is certainly just as satisfactory as would have been the case if a natural stone had been used.

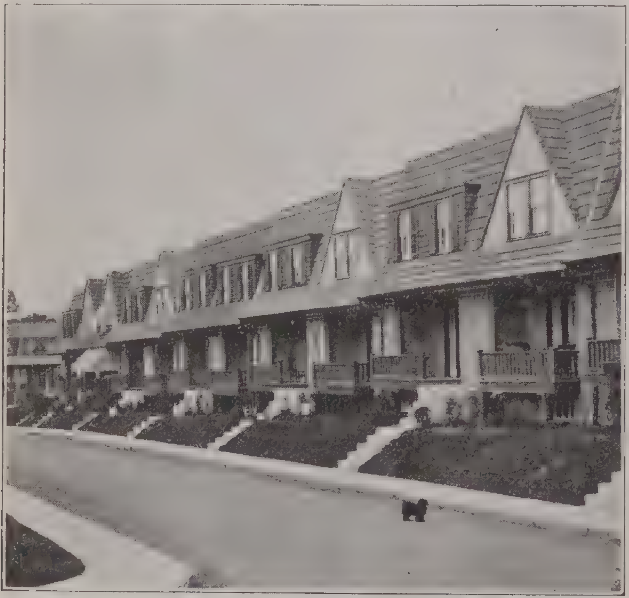


Fig. 5. Even in long rows of houses, interesting effects can be attained through the use of concrete block

These photos, selected at random, show strikingly how, with a little ingenuity concrete block can be used without covering provided the architectural design is handled by someone who knows how to use them properly. In the erection of small houses which are to be sold at a low cost this type of construction has considerable possibilities and block manufacturers would do well to show these photos to architects and builders with whom they are working as an illustration of what can be done along these lines.

Indianapolis Concrete Products Association Inspects Plants at Cincinnati

Headed by O. L. Miller, president of the Indianapolis Concrete Products Association, a delegation of nine members of that organization recently accepted an invitation extended by the Cincinnati Concrete Products Association and inspected concrete products plants in Cincinnati and vicinity. Besides Mr. Miller, those in the visiting party were Paul Burkholter, George Bradshaw, S. H. Tompkins, J. G. Praed, C. J. Rath, F. J. Schuster, Fred D. Stiltz and G. C. Harr.

Among the factories inspected was the Gubser plant at Newport, Ky., and also that of Robert Simms in the same city. From there the delegation went to Norwood, Ohio, and visited the plant of S. I. Crew. Following this, the plant of the Cincinnati Cast Stone Company and those of Herman Forstee and George Potter of Cincinnati were inspected in order.

All of the Indianapolis members expressed great interest in the trip and especially in the quality of products being produced in the territory served by the members of the Cincinnati association. The Cincinnati ordinance requires that concrete block stand a compression strength of not less than 1000 pounds per square inch gross cross-sectional area and all of the members are more than meeting that standard.

The visiting Indianapolis delegation was entertained at dinner by the Cincinnati manufacturers, which was followed by a lively discussion led by S. I. Crew, president of the Cincinnati association, who first called on members of the Indianapolis organization for remarks. These were devoted for the most part to expressions of appreciation and tributes to the success that the Cincinnati organization has enjoyed.

George Potter of the Cincinnati association then told of the good that had been accomplished through their association and was firm in the belief that it was the outstanding factor that had put the products game on its feet in Cincinnati.

Another interesting talk was given by Mr. Ritter, who has been in the products business the longest of any producer in Cincinnati. He related some of the early aspects of the industry and compared them to newer developments of the present time.

It was stressed that the thing that had made the products industry successful in Cincinnati was the strict enforcement of the new ordinance, and the fact that it called for the high standard of 1000 pounds per square inch on the products. It was also pointed out that it did not cost much, if any, more to make a product of this standard than one of lower quality. Breakage alone in a plant would make up the small difference in initial cost, and there was besides much to be gained by the increased respect and confidence with which architects accepted the better product.

In making the trip to Cincinnati, the Indianapolis organization set a precedent which will undoubtedly be followed by other products associations. Such trips serve not only to stimulate the members to closer cooperation but the interchange of ideas is sure to be beneficial to both the visiting delegation and the inviting group.

EDITORIAL

Cement for Products Plants

There are sound arguments on both sides of the much discussed question of the advisability of selling cement direct to products manufacturers. It is a question on which products men are not of one opinion. Nor are the cement manufacturers agreed on it.

A few cement manufacturers now sell their material direct to a few selected products plants on the theory that the products manufacturer in turn sells the cement—in the form of precast concrete units—to the contractor for use on the job. Thus, they say, the products manufacturer is in reality a dealer and as such is entitled to the dealers' discount.

The products man sees the viewpoint of the cement manufacturer and admits that there is some basis—or at least that there was some basis—for the mills to refuse direct sales. There are still many products makers whose output is small and whose credit is limited. These men appreciate the services rendered by the local material dealer. For a mere 10 per cent he is willing to see that there is always an adequate supply of cement on hand; he carries purchasers on his books that are not able to buy on the basis that would be required by the cement manufacturer; he cleans, bundles and returns empty sacks and provides for the usual refund. In short, he provides a service that the small products manufacturer needs and one that reduces credit losses and simplifies the work of the cement manufacturer.

On the other hand, there are many, many large and well-established products firms whose credit is of the best and whose output requires the use of cement in as great or greater quantities than the local dealer can use. These firms are thoroughly organized and rank with the best of business enterprises in the community. They are equipped to stock large quantities of cement, to clean, bundle and return the sacks. In every respect they are as desirable customers as the dealers.

There are thousands of these producers throughout the country and it is these men that demand the opportunity to obtain their cement direct from the manufacturer. They insist on being independent from the local material dealer who often is more interested in competing materials. And they ask the privilege of the dealers' discount inasmuch as they perform all the duties that the cement dealer assumes with equal safety to the cement manufacturer.

Their requests are not unreasonable. As the products industry grows, some uniform policy for selling cement to products plants will have to be worked out.

Proportioning by Trial

There has been much unnecessary awe among engineers and contractors of this matter of fineness modulus and water-cement ratio. Revolutionary as it may seem, it is entirely practical to specify that the proportions for concrete "shall be one sack of cement to six gallons of water to as much fine and coarse aggregate as the contractor cares to use." Then if the contractor will adjust his mix with the materials at hand until he gets the greatest workability, he is applying the theories of fineness modulus and water-cement ratios in the most practical way.

Such a method of determining the mix by trial will produce concrete of a definite predetermined strength just as surely as the more elaborate (and to some, terrifying) juggling of seive analyses and fineness moduli. It is a simple, easily understood and easily executed method and it has proved its practicability on the job and in the field.

This method is based upon the demonstrated fact that, given materials that are clean and structurally sound, the strength of the concrete depends entirely upon the quantity of mixing water used per bag of cement. By regarding the cement paste as a glue binding the particles of aggregate together, this fact will be easily understood. The addition of excess water serves only to dilute the glue and reduces its strength. Any reasonable amount of aggregate may be used without changing the strength so long as the resulting concrete has the workability and the finishing qualities needed for the work in hand.

No involved calculations are necessary. Concretors everywhere can use this method with the assurance that it will produce good concrete. In this way they are applying the principles of scientific proportioning and designing concrete without the complicated computations they dreaded and regarded as high-brow and impractical.

The New Cement Specifications

Committee C-1 of the American Society for Testing Materials has decided upon certain changes in the standard specifications for portland cement at the annual meeting of the society last month. No startling changes were proposed. The specific gravity test was dropped from the specifications entirely as being of little or no use as an index of the quality of cement. The seven day tensile strength requirement was raised from 200 pounds to 225 pounds. The 28-day tensile strength requirement was also increased a like amount—from 300 pounds to 325 pounds.

These changes in the standard specifications will undoubtedly meet with the approval of many engineers because they are an attempt to meet the demands of some testing engineers for more rigid specifications. In that respect they are an evidence of the desire of the cement manufacturers to cooperate with the user.

But, like the former specifications, they are not an adequate measure of quality. They are useful but not accurate. They provide a crude tool for measuring quality inasmuch as experience has shown that cements passing these requirements will, if properly handled, make good concrete.

Inadequate as they are, the proposed specifications are as effective as it is possible to make them with the meager knowledge now available. Without a thorough understanding of the chemical and physical properties of portland cement it is obviously impossible to evolve methods of accurately measuring the quality of a material about which there is so much difference of opinion. Until accurate, comprehensive data are at hand upon which adequate specifications can be founded, the new revised specifications must suffice.

Special Concrete for Highway Construction in Europe

(After *Zement*, by E. Lee Heidenreich)

Especially in Belgium and in France investigations of special highway concrete have taken place, using peculiar compounds or special cements, and among the former the Rhoubenite method is worthy of particular attention.

Rhoubenite is a concrete consisting of common portland cement, sand and broken stone, to which is added the patented Houben-powder.

The inventor, a Belgian engineer by the name of R. Houben, endeavored to produce a concrete which would not be subject to the fine cracks, which through the atmospherical action has such deteriorating influence.

The Rhoubenite powder does not act as a surface waterproofing cover, but by its nature adds to the impermeability and elasticity of this concrete, without impairing the strength.

The Houben powder consists of a sort of sawdust mixed with certain hydrocarbon liquids in correct proportions, and this mass is uniformly distributed into the concrete as the so-called Rhoubenite, which through its consistency adds to the elasticity of the concrete.

By carefully controlled mixing, the concrete mass becomes absolutely impermeable to moisture, without any reduction in strength.

The mixture of Rhoubenite concrete is as follows:

Crushed stone	¾ in.–1½ in.	550 liter	19.3 cu. ft.
Crushed stone	¼ in.– ¾ in.	550 liter	19.3 cu. ft.
Sand or stone dust		450 liter	15.7 cu. ft.
Cement		400 Kg.	880 lbs.
Rhoubenite powder		60 liter	2.1 cu. ft.

This yields 1100-1150 liter (38.2—40.0 cubic feet) of concrete.

The water added amounts to about 150 liter (5.2 cubic feet), so as to give a very dry mix. The Rhoubenite is added after the concrete is perfectly mixed, and then the entire mass again is mixed and quickly placed.

Artificial expansion joints are located similar to the methods used in United States—particularly as Rhoubenite rather increases the co-efficiency of construction.

Streets have been built with this material in Bruges, Lille, Antwerp in Belgium, and in Paris, St. Genis, Loval, Boulogne-sur-Seine, Grenoble, Rouboix, Perreux, La Baosie and others in France.

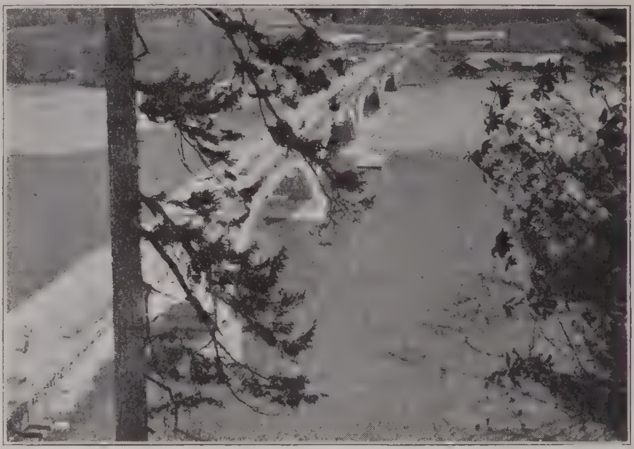
Concrete Tables for Dishwashing

Concrete tables for dishwashing are a new departure in kitchen equipment that have been worked out by Manager B. B. Morton of the Rice Hotel, Houston, Texas. Mr. Morton claims that the tables which he has had specially built for his hotel are proving more satisfactory than any which he has ever used.

These are built upon 2-inch cast iron pipe legs, flanged at both ends; the bottom and sides of the table proper having a base of channel iron turned to make the sides. It is then lathed and plastered with one coat of rich cement mortar, allowed to dry, and then another coat of mortar, followed by a concrete mixture 1:2½:4 and finished off with a cement mortar and a hardener.

Mr. Morton, in writing to the *Hotel World* concerning the tables, says: "I don't know that this table saves us anything in breakage, but I do know that our breakage is not any higher than it was formerly. We have also placed a rubber mat in the bottom of this table which is sterilized with steam and dried daily. The feature that appeals to me in connection with this table is its permanency. We formerly had to recover our tables annually at quite an expense. This cement table will eliminate this annual maintenance cost, at the same time being clean, sanitary and without breakage more than ordinarily occurs on any other table.

Douglas Memorial Bridge Across Klamath River Nearly Completed



The reinforced concrete arch bridge constructed by the California Highway Commission across the Klamath River on the Redwood Highway in Del Norte county and known as the Douglas Memorial bridge, is nearing completion. When completed it will be the largest bridge on the California State Highway system. It consists of five reinforced concrete arch spans, each 210 feet in length, with two 50-foot approach spans, making the total length of the bridge 1,150 feet. It will have a clear roadway width of 21 feet.

Asbestos-Concrete Pipe to Convey Mail in Lucerne

A new wing to the railway station in Lucerne, Switzerland, is now under construction, which, upon its completion, during the latter part of 1926, will provide additional space for railroad, postal and customs administration as well as a new arrangement for waiting rooms, writing rooms and restaurants for the convenience of travelers, states a report to the Department of Commerce from Vice Consul George R. Hukill, Lucerne, Switzerland. Not only is the station itself being enlarged, but plans for the widening of adjacent streets and the relocating of tram lines to avoid traffic congestion in the vicinity of the station are under consideration. In connection with the new addition to the station, there is being constructed an underground conveyor for the transportation of mail from the mail depot in the station to the postoffice, a distance of approximately 150 meters. The work is attracting attention from a technical point of view because of the use of an asbestos-cement pipe made of a patented material termed "Asbeston" for the pipe line through which the conveyor will operate. The conveyor itself will be in the form of a mechanically operated belt line running through the pipe system and on which will be transported all classes of mail matter from the station to the postoffice.

Many a products plant has an imposing silo or storage bin going to waste. With a great wall space, readily seen by all who pass that way, what location could be more adaptable and valuable for advertising space? The practical products manufacturer will paint a sign in big letters on this space telling whose plant it is and what is made therein. He will there display his faith in the importance of his business and the excellence of his own products. It will be advertising well worth while.

Making Lighting Standards in Seattle

"I am sold on the idea of concrete light poles," is the statement of J. D. Ross, superintendent of the municipal lighting department of the City of Seattle. As a consequence of this opinion the city light department has just taken delivery of 300 standards constructed of reinforced concrete, which were made according to specifications of that department by a subcontractor, NePage McKenny Company of Seattle.

Several blocks along two main thoroughfares of Seattle are now equipped with the new light poles. They stand 18 feet in the air and support two 600 candle-power lamps. The standards are placed 80 feet apart. In two suburban districts similar poles topped with one lamp are used. Thus the plans of one of America's best lighted municipalities have been revolutionized. The system of street lighting heretofore followed has included the setting of cast iron poles, some with cluster lights, others with one or two lamps.

Despite the precedent established and adhered to for years the change has now been definitely made to concrete poles. "Reasons may be had aplenty," says Mr. Ross. "The original cost of the concrete poles is about one-half that of the cast iron ones. The upkeep of the poles is practically nothing; there is no deterioration from weathering, and if injured by collision or other mishap they easily can be repaired. Also, the concrete pole is stronger than the iron one," says Superintendent Ross.

The process now employed by the NePage McKenny Company in making the concrete poles is one which has been evolved through considerable experimentation. The first poles made were jogged rather than tamped. This method has now been replaced by the centrifugal process.

Considerable preparation of especially designed equipment was necessary before the process could be built up. Cast iron molds were first made in two equal sections, divided longitudinally. These were later replaced by steel molds similarly constructed. Three steel molds are sufficient for the making of three poles daily. These molds are carefully finished inside to procure a smooth surface.

Casting the Poles

A medium sized power mixer furnishes the wet concrete which consists of one-one-two or a one-one-one mix, depending somewhat on how "cold" the cement may be procured. Pea or roofing gravel is used. A small electric lift elevates the concrete to the top of the molds. A trestle some hundred feet in length furnishes ample room for the pouring process and takes care of a week's or more supply of finished poles.

The core and reinforcing for the poles consists of four half-inch iron reinforcing rods extending the full length of the pole. Around these four rods is wound a spiral of number eight wire spaced about 9 inches. Where the wire touches the rods it is held firmly in place by tying with additional short wires. The four rods are hooked into pedestal irons which are allowed to project from the concrete at the base. Each iron is bored so that the pole when set in place may be securely bolted to the sidewalk. Through the center of the core is run a black iron 1-inch pipe or conduit for the purpose of carrying wiring.

Oiling the Mold

With the core finished it is sufficiently rigid to stand erect and be easily movable. The molds are next wiped wiped with a rag saturated in lard oil. A thin coating of the oil is placed over the inside of each mold. Care is used to see that the oil coating is heavy enough to withstand the pouring of the mixture through the top of the form without erasure, and yet not so heavily applied as to run to the base when the mold is placed upright.

With the core in place in the center of the mold the whole is bolted firmly to a 30-inch steel disc attached by a worm gear to an electric motor. The apparatus is so geared that it will make 250 revolutions a minute.

Spinning the Mold

The mold is now ready for pouring the mixture. Rotating of the form as the mixture is slowly poured eliminates air voids that are frequently found in tamped concrete, also it brings the water, sand and cement to the outer rim of the pole and completely covers the gravel imbedded in the interior, leaving the surface of the finished pole smooth. Thirty minutes of rotating is required to finish the pouring process. At the expiration of 14 hours the poles are sufficiently set to allow removal of the mold and to permit their handling. They are lifted with a pulley and by a cap screwed on the end of the inch conduit which is run through the center of the pole.

In the jogging process, which was tried first after abandonment of the tamping method, it was discovered that the oil with which the mold was coated collected at the lower end of the form and scarred the pole. The jogging was done mechanically by electric power in a fashion similar

to that used in rotating the mold.

The standards made for the city support variously designed cast iron mountings for the lamps, dependent upon the lighting needs of the street. A thoroughfare serving as an artery for wheeled traffic is lighted by 18-foot standards bearing two 600 candle-power lamps, throwing a maximum light of 1.01 foot candles on the center line of the street, and a minimum of .43 foot candles at any place within the circle of light.

On those avenues comprising the retail and financial districts of the city a diffused lighting effect is obtained by a 14-foot pole bearing five lamps. This cluster system is employed to avoid detracting from the myriad of electric sign displays used by the Seattle business houses and buildings.

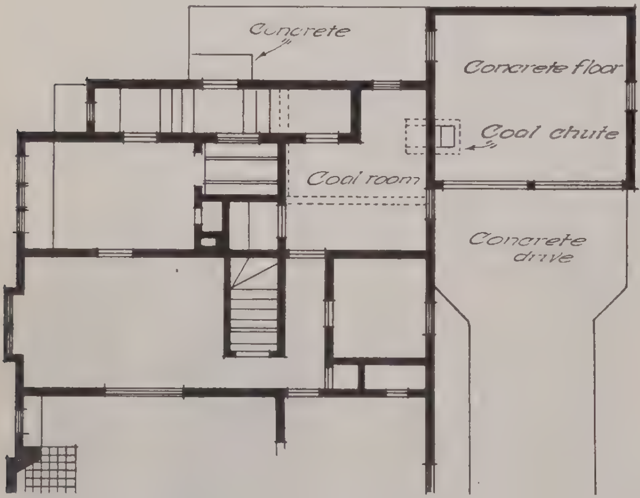
While the contract with the city to supply its immediate needs is finished the company is making many poles of similar design for private companies and will resume construction for the municipality when more poles are needed.

Concrete Helps the Home Owner

The partial floor plan shown herewith illustrates a few things that the contractor may do with concrete when erecting a small residence—extra things that add far more than their cost to the re-sale value of the property.

At the northwest corner of the kitchen the little recess on the outside wall is filled with a concrete wall, or border, around a flower bed. The rear door—the side entrance—has a concrete step and an area six feet wide and fourteen feet long, also of the same material—providing a clean place for washing off muddy overshoes or sweeping the rugs.

A wide concrete drive extends from the street and leads to the double garage which is set against the house. The drive extends right into the garage and there forms the floor. In the basement, concrete walls partition off one corner—next to the garage—for the coal room. A concrete chute leads into this coal room and terminates at the surface of the garage floor, near the left wall, where the coal wagon can back in and unload without muss even in stormy weather. The upper end of the chute is covered with a reinforced concrete slab cover, recessed into the floor so that it fits flush when in place. This merely forms then, part of the garage floor.

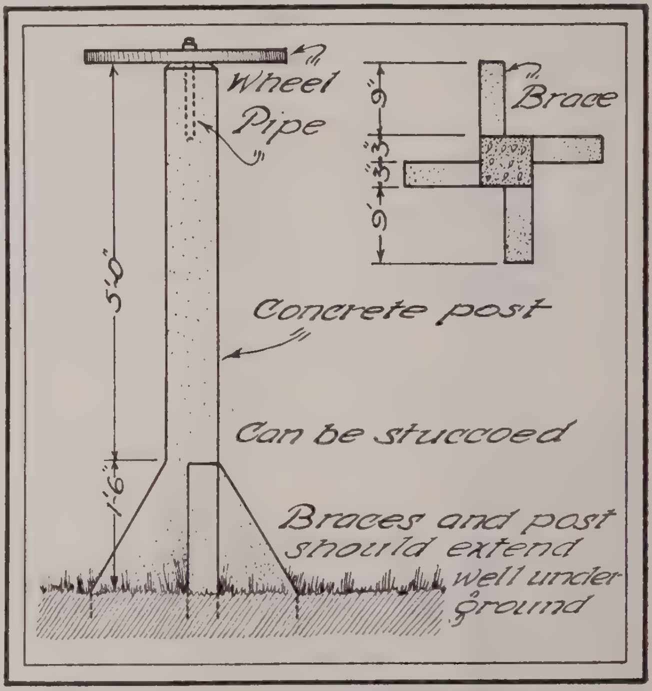


A bird bath for the back garden, a circular concrete flower bed for the front lawn and a concrete lily pond and other things are placed in the yard.

A Clothes Drier Post Made of Concrete

The accompanying drawing shows how a good post was made for a clothes drier. It has been in use for a number of years and still is free from cracks or apparent weaknesses. Since the quantity of sand and gravel and cement required is small, and the forms easy to build, its cost is but little. Yet it forms a substantial, durable support for a clothes drier of large capacity. Odd jobs like this bring extra profit between jobs.

The post is six inches square above the braces and extends six feet into the air. The braces and post extend two and one-half feet below the ground level. A small pipe has been set into the top. This serves as bearing for the wheel which is mounted on top. Arms of hardwood or galvanized iron (such as a pump rod) are attached to the wheel and these extend in the general direction of the spokes, with ropes tied from end to end, and just short enough to cause each arm to bend upward slightly. If the arms are each six feet long, there will be room for three complete rows of rope about the drier. This will give an approximate linear drying capacity of from 30 to 33 feet.



If the ground is compact no forms will be needed underground, but the hole itself—dug to shape—may be used instead. If the ground is soft, however, the forms for both braces and the post should extend to the bottom of the hole. If desired, triangular strips of wood can be tacked into each corner to give the finished post a bevel on all edges.

Mix the concrete in the proportions of one part cement to two parts of sand to three parts of gravel and puddle the mortar all the way up to prevent honey-combing. If desired the post and braces can be covered with stucco to match the house, or the surface aggregates may be exposed by means of washing the post with a solution of muriatic acid.

The Kansas State Agricultural College is now conducting two investigations of interest. One deals with abrasion tests of concrete, while the other covers the twenty-four hour test strength of sand for concrete, using Lumnite cement.

Interesting Kinks Used on Turner Job

The Turner Construction Company Has Been Using Interesting Methods on The Portland Cement Association Building—Placing Sub-Basement Wall Before Excavating—Measuring Water in the Mix—Placing Thin roof Section in Sub-Zero Weather—Concrete Units in Partitions—Facing Backed by Reinforced Concrete

Wherever one finds a job under construction by the Turner Construction Company it is well to stop, look, and listen,—for a number of interesting things are usually to be observed. This is especially true on the job known as the Portland Cement Association building, in Chicago, where the owners themselves have called for work that, to say the least, is not seen everywhere.

To begin with, the caisson contractor turned over the job to them with a real problem to solve without delay. One side of the building abuts on an alley, and the subgrade of that alley was none too secure. On another side was an ancient brick structure, several stories high, that was carried on nothing but stone footings resting on wet clay. All signs pointed to a mean job—and a wet one. To begin with, the old building was shored up and the footings made secure. The basement excavation was then completed, to 14 feet below the street level, and wood sheathing driven into place on the alley line. This was braced securely as shown in the illustration. The next step called for digging a trench down to the tops of the caissons, 30 ft. below the street, wide enough to permit placing the footings. This trench, well braced and sheathed, was then used as a form for the footings. When this concrete had hardened, and the basement walls carried up to grade, it was a simple matter to go ahead with the rest of the structure. The sub-basement was not excavated until later on, after several stories had been erected.

In the erection of the superstructure the latest and most scientific methods were used. A unique form system that reduced labor costs materially was devised by the superintendent. By means of this system, column forms were easily erected, panels were dropped into place without a lot of the usual fitting, and a minimum of shoring was needed. These forms were so accurately made that but little finishing was found to be required after stripping, especially since the concrete itself was well rodded into the forms and the mix was scientifically designed. When it was time to drop the panels for re-use, the system permitted doing this without removing the shores, because of their resting on special panels, and thus more carpenter and other labor was saved. The column forms themselves were stripped without any great labor expenditure. Double-headed nails made stripping easy. A portable electric handsaw permitted rapid and economical reduction of column forms. This system was described in the March, 1926, issue of CONCRETE.

The mixing plant itself was worthy of some attention. In order to obviate blocking the street with materials, aggregates were delivered only as needed, dumped on the ground, and loaded into the mixer after shoveling into buggies. The cement was stored on a small platform slightly below the street level. A chute led from the street level to the charging hopper of the mixer. Since care had to be used in measuring the water for each batch a special water can was devised by the engineers. It was found easy to set this can for any volume and be certain that too

Two views of the substructure work on the P. C. A. Building. At the left is a view looking down in the trench along the alley, where the retaining wall is being placed upon the top of the caissons. At the right, the shoring that held the alley in place much water would not inadvertently go into the drum. Moisture calculations were made on the job, and the amount of moisture found to be in the sand was deducted from the total amount required inorder to determine the amount to be measured by the can. A flexible apron at the discharge opening of the mixer prevented the concrete from slopping into the pit instead of running into the hoisting bucket. The mixed concrete was hoisted and chuted to a distributing hopper, from where it was taken to the forms in the usual buggies.

The reinforcing itself was accurately placed, and was supported on a special chair. This was made up of sheet metal, notched to carry a one inch tee bar, and which carried the reinforcing bars. These chairs were made by a local concern and had the advantage of economy and efficiency.

It is of interest to note that, on some floors, a reinforced concrete curtain wall was formed, and to this curtain wall the Benedict stone facing was anchored by means of dovetailed slot anchors. On other floors the stone facing was backed by concrete brick manufactured by a local concern. The partitions throughout the building are of cinder concrete partition units. The superintendent stated that the masons had little trouble laying up the concrete brick and Cincrete tile once they got used to handling them. Often a little lime in the mortar made laying easier, although the rough texture of the units provided good mortar bond.

Another interesting point observed on the job was the fact that thin concrete sawtooth roof sections were formed without great trouble in spite of the fact that the temperature was about 20 degrees above zero when that part of the work was started but dropped to 16 degrees below zero before much of the concrete had been placed. The superintendent claimed that the good results apparent to the visitor were secured simply by housing the work over tightly by means of a tarpaulin enclosure and then putting into use a great many salamanders. Thus the temperature was kept well above the minimum desirable point and kept there until the concrete was well set.

Los Angeles Specifies Cement in All Mortar

Although Los Angeles is located in a region occasionally subjected to earthquake shock, that city has until recently permitted the use of untempered lime mortar for all brickwork, in any part of a structure.

Recently this situation was corrected through the adoption of Ordinance No. 54,621, passed by the city council on March 30 and approved on April 9, 1926. The ordinance amends Section 121 of the Los Angeles Building Code to the extent that all unit masonry construction must be laid up in mortar consisting of not less than one part of portland cement to nine parts, by volume, of lime mortar, the latter composed of not less than one part of lime to three parts of sand. This produces what is virtually a cement-tempered lime mortar, consisting roughly of one part of cement, three parts of lime and nine parts of sand, by volume.

The statement of proportions as one sack of cement to nine cubic feet of lime mortar is due to the prevailing custom in Los Angeles of delivering lime mortar from commercial mixing plants. Under those conditions the cement that is now required is added on the work, just before the mortar is used. Lime mortar produced at commercial mixing plants ordinarily is allowed more time for slaking than in cases where the mortar is mixed on the work. For this reason this method of delivering lime mortar is encouraged by the city building department of Los Angeles.

Hard-Surfaced Floor Patented in Germany

The question of mechanical wear is one of the most important in the case of floors for railway stations, stairways, locomotive sheds, sliding planes of silos, ore and coal bunkers, boiler houses, concrete railway vans, and the like. A German professor has obtained home and foreign patents for a so-called steel-concrete process by which a steel-like metal skin is produced. It can be made of any desired thickness, is homogenous and offers, it is said, the utmost resistance against mechanical wear on concrete, brickwork, cork and natural stones. Authorities have made experiments and found out that the degree of hardness is eight times as much as the best machine-pressed plates of artificial stone. The connection with the basis is very good provided the instructions are carefully carried out when applying the skin. The latter allows treatment similar to cast iron, viz., planing, drilling, filing, sawing and grinding. When the borer has penetrated such a plate the hole shows quite smooth surfaces, which is not the case with wood and several metals. The tensile and bending strength is claimed to be about double that of best concrete, and the compressive strength from three-quarter times as high.

An important peculiarity is the absolute water-tightness. The Technical College of Darmstadt (Hesse) is reported to have made numerous successful experiments. A layer of this steel-concrete ½ centimeter thick, merely put on by hand and not pressed on the surface, resisted, it is said, a water pressure of 14 atmospheres for nearly 200 hours without showing leakage. The process is extremely simple. The material is produced cold and applied in this state by some average unskilled workman after a short period of instruction. It has been tried with whole coherent surfaces and separate plates.

Concrete Culvert Pipe Design Under Investigation

The Highway Research Board of the National Research Council is now working on an investigation of the design of concrete culvert pipe. R. W. Crum, engineer of materials and tests, Iowa State Highway Commission, has been designated chairman of that investigation. The objects of this study are to correlate the various tests and experiments on pipe loads and stresses; to set up a standard of comparison of the life of different kinds and classes of culvert pipe; and to determine the most probable conditions of service for which standards should be designed.

Mr. Crum's experience in research work well qualifies him to head this important investigation. After graduation from the Iowa State College in 1907 he was for a time on the engineer corps of the Pennsylvania Lines, following which he returned to his alma mater as assocate professor of civil engineering. He remained in this position for 12 years, during which time he was engaged on research work for the Iowa Engineering Experiment Station. Since 1919 he has been engineer of materials and tests with the Iowa State Highway Commission where he has conducted many highway research studies. Mr. Crum is the author of a number of important research papers. He is a member of the American Society of Civil Engineers, the American Society for Testing Materials and the American Concrete Institute, and is active on several research committees of those organizations.

According to Thomas H. MacDonald, chief of the United States Bureau of Public Roads. the annual improvement of over 40,000 miles of highway will not only continue for this year, but for several years to come.

Floor Tests That Dispute Theories

Tests on Old Warehouse Showed Strength That Could Not be Reconciled with Ideas of the Joint Committee—The Design of the Building and Its Construction—Unexpectedly High Strength Apparent.

By WALTER H. WHEELER

Recently the writer was called upon to make an inspection and report upon a reinforced concrete warehouse building in a large western city which had been condemned by the building inspector of that city as unsafe for a load of more than 100 to 125 lbs. per sq. ft. although the floors were originally designed for a live working load of 250 lbs. per sq. ft. It is the writer's understanding that the building inspector's order was based upon a report by a certain firm of engineers who had made an inspection of the building and the design.

The building was built some 13 years ago and was constructed during the fall and early winter months. The floors are of the flat slab type commonly known as the "Mushroom" system. There are 3 floors and a roof. The roof is of timber mill construction, and was added at a later date. The design provided for future additional stories on the building. The column diameters are as follows:

	Interior Columns	Wall Columns
2nd STORY	18″	16″
1st STORY	20″	18″
BASEMENT STORY	22″	18″

The plans called for a 9-inch flare of the column capitals on the interior columns, but the building was constructed with 6-inch flares. No column capitals were called for on the wall columns and none were built. The rough concrete floor slabs were shown 7 inches thick and the cement finish was to be 1 inch thick. There are no depressions or drop panels in the slabs over the columns. The slab reinforcing is the four way type and consists of 12 ⅜-inch plain round rods in each belt. The vertical column rods are bent out into the slab and the belts of slab rods pass over the columns at the top of the slab two ways directly and two ways diagonally. There is no other reinforcing in the slab except where openings require special construction. The interior columns are spaced 16 ft. center to center both ways.

Carried Heavy Loads

An inspection of the building disclosed the fact that the slabs had been permitted to sag as much as 2½ inches in some panels during construction and the depressions filled up or nearly filled when the cement finish was applied to the floors. Partitions in the building do not indicate that the floors have sagged since the partitions were built.

Those who are in a position to know the history of the building state that the floors have been loaded frequently to 300 and 400 lbs. per square foot by the owners during the time they used the building.

After the writer had made his examination he suggested that the floors be tested to establish their safe carrying capacity. This suggestion was adopted and the tests were made, in the presence of two representatives of the building inspector's office.

Prior to the test the writer advised the building inspector that he would expect the deflection at the center of the test panel would be about $\frac{3}{16}$ inch under full live load. The test panel was loaded in lifts of 125 lbs. per sq. ft. Readings were taken before the load was applied and after each successive load was placed until the load equaled 500 pounds per square foot over the full area of the test panel. The deflection increased uniformly and at 500 pounds per square foot equaled just ⅜ of an inch. This load was applied on the first floor which has a clear story height of about 14 feet 4 inches. The load was allowed to remain on the floor for twenty-four hours and another reading taken which showed no change in the deflection. The load was then removed and another reading taken which showed the recovery of the slab to be complete.

The second floor was subjected to a similar test but the load was only carried to 350 lbs. per square foot as the height of the second story is only 10 feet 4 inches and it was not possible to place 500 lbs. per square foot on the floor without bringing in other materials than were at hand. The deflections were in proportion to the load and corresponded with those for similar loads on the first floor.

Not Universally Correct

This test is interesting for several reasons.

First, because it was made on a building which had been in constant use as a warehouse carrying heavy loads for thirteen years.

Second, because it indicates, as have numerous other tests, that the theory of flat slabs proposed by the joint committee is not correct for all types of flat slab design.

Third, because it indicates that the building industry is being penalized by building ordinances which make the use of drop panels mandatory for all types of flat slab construction, require excessively large column capitals for light floor loads and require an excessive amount of reinforcing in the slabs.

The writer criticized the proposed design rules of the joint committee last year before the American Concrete Institute and in the Proceedings, of the American Society of Civil Engineers.

Some Discrepancies

It is interesting to note:

1ST. That by the rules for flat slab design proposed by the Joint Committee, the slab tested has the thickness required for a live load of only 30 lbs. per sq. ft. To carry 250 lbs. sq. ft. live load would require by the said Joint Committee rules a 10½ inch slab.

2ND. That the slab tested has the minimum diameter of column capital required by said rules for a live load of only 70 lbs. per sq. ft. The diameter of capital required by the said rules for the same slab thickness would be 68 inches.

3RD. That the slab tested has sufficient steel according to the said rules for only 50 lbs. per square foot live load. The said rules would require 28⅜ inch bars in direct belts and 22⅜ inch round bars in diagonal belts.

The slab tested carried a test load 16½ times as great as the slab thickness provides for according to the said rules. It carried a test load 10 times as great as the steel provides for according to said rules. It carried a test load 7 times as great as the diameter of the column capital provides for according to said rules.

The building tested could not be built today to carry even its own dead load under many of our city building codes as they exist today. Yet it has done 13 years of heavy service and at the end of that time behaves perfectly under a test load double the design load.

The building on which the load tests herein described was made was not designed by the writer and he had nothing whatever to do with either the design or the construction.

With more than $200,000,000 invested in commercial sand and gravel plants throughout the country, and a vast supply of graded clean material, there is no real reason why a contractor need take his aggregates from a pit where no attention is given to these matters, and takes his chances with material whose value is doubtful.

An All-Rubber Core in Making Concrete Pipes

By A. C. BLACKALL

London, England

There has just been held in Mosman, New South Wales, Australia, a very interesting public demonstration of concrete pipe laying. A trench was prepared and in this trench was placed a long rubber tube. This tube was connected by pipes with a Sullivan air compressor and was inflated under pressure until it reached the diameter decided upon—in this case 14 inches.

Meanwhile the concrete mixer had been put into operation, and workmen shovelled the concrete into the trench, forcing it round the rubber core. Only a few minutes' work were necessary to complete a pipe 30 feet long. The core was allowed to remain until the concrete had set and was then withdrawn without difficulty, and another section added.

J. H. Tonkin, the engineer in charge of the demonstration, explained that the method of constructing culverts, using a flexible, baglike core, was already quite well known. The core, however, has hitherto been made of nonextensible material, such as cotton fabric lined with rubber, and the difficulty in such cases has been to withdraw the core after the pipe has been constructed. The difficulty was considerably accentuated when the pipe was curved. The rubber core demonstrated, however, became smaller along its whole length when deflated, making the matter of withdrawing it very simple. The appliance is a Japanese invention and is being extensively used in concrete work in the Orient.

Signs

The weekly Letter No. 8, issued by the Wisconsin Concrete Products Association, has the following to say with regard to signs at the products plant:

> "Concrete products manufacturers, as a rule, have no signs at their plants as is the usual custom with any manufacturing concern. We have continually urged the products manufacturer to let the public know who he is, what he does, etc.
>
> "About the least you can do is to put an appropriate sign on your plant, telling the passing public to whom it belongs, and what is made there. Let's each one of us plan on putting up some very neat, appropriate sign at our factories.

First Five Months of 1926 Show Increase Over Previous Year

The amount of construction performed during the first five months of 1926 exceeds the total for the corresponding period of 1925. Construction activities during May of this year also showed an increase of 18 per cent over the volume of work registered for April, according to statistics compiled by the Associated General Contractors of America.

The volume of contracts awarded during the first five months of this year exceeds by 16 per cent the volume registered during the corresponding period last year. Figures on building permits issued since the first of the year are practically equal to those covering the same period of 1925. The totals on contract awards and permits issued in April were slightly lower than the awards for April, 1925.

Construction costs rose during May to the highest position they have reached since July, 1925. This increase, coming despite the fact that prices of construction materials dropped appreciably during the month, reflected wage increases. Wages in the construction industry last month reached the highest average they have held since 1920, an increase of two points, placing them at an index number of 228, based on the 1913 figure.

The average prices paid for construction materials was lower last month than in May of any year since 1922. Drops in prices of cement and common brick in some sections were responsible for continuance of the decline, which has been steady since June, 1923.

To Reconstruct Old Mission With Reinforced Concrete

The old mission at Santa Barbara, Calif., will soon be so reconstructed, it is planned, that it will be preserved for generations to come, yet no detail will be in any way altered. The reconstructed building, which is architecturally and historically well worth preserving, is to be so rejuvenated that it will preserve the same impression as the old, not only in color values and textures, but also in contour and age. The old eccentricities of the floors and walls, none of which are in either horizontal or vertical planes, have been carefully measured and will be retained in the renovated structure.

As planned by the architectural board, it is their intention to chase the walls of the lower story for reinforced concrete columns to be carried down to spread footings at a sufficient depth to carry the structure. These columns will support reinforced concrete girders and beams that will carry the concrete and tile floors. In the monastery section, all exterior and interior walls will be rebuilt of reinforced concrete. Stone walls ars to be reconditioned with the cement gun, while all fissures are to be filled with grout and tied together with iron anchors and tie rods, and finally plastered to match the old work. The entire roof of the mission, with the exception of the larger timbers crossing the nave, will be removed, and rebuilt with the old timbers and structural steel—after a reinforced concrete plate has been cast at the top of the wall. The roof will then be recovered with the old tile. Both towers, which are about at the point of collapse, will be torn down and rebuilt with reinforced concrete and stone, with every original detail carefully restored. The old stairs will be preserved entire. Buttresses supporting the nave are to be brought back into alignment by means of anchors and reinforced concrete. Thus this adobe structure, built a century ago, may be made to live for centuries to come.

Code Recommendations to Building Officials

Recent Conference of Building Officials Gave Light to Two Reports on Masonry Units—Progress Report on Solid Building Units—Final Report on Hollow Building Units

The Committee on Solid and Hollow Building Units, of the Building Officials' Congress presented two very interesting reports at the meeting held last April, and since they will probably be eventually used by code-making bodies throughout the country from time to time, the reports are here given in full. The report on solid building units was presented for the first time this year and is therefore a tentative report, subject to future revision. The report on Hollow Building Units, however, is a final report, and is ready for use. The committee making these reports was made up of W. C. Muehlstein, Charles A. Bowen, Robert K. Cochrane, J. R. Hesser, H. Ray Kingsley, Robert Knight, and Norman M. Stineman. Each report was signed by every member of the committee except Mr. Cochrane, who was not present. These reports are presented to our readers knowing that the information contained therein may be helpful.—The Editors.

Progress Report on Solid Building Units

Section I.—Definitions

1. By *solid building units* is meant incombustible material, artificially molded to solid form with not more than 12 per cent of hollow spaces or voids which are designed to reduce the total weight or volume of material in units which are used in the construction of buildings and similar structures.

> NOTE: In this report it is not the intention to include natural stones cut or otherwise formed to a desired shape.

2. By *building brick* is meant solid building units conforming in size and shape to the requirements of Section III.

3. All solid building units which do not conform in size and shape to the requirements of building brick shall be classified as *solid building block.*

Section II.—Classification

1. For the purpose of establishing appropriate use solid building units shall be classified as hard, medium or soft in accordance with the requirements contained in the following paragraph.

2. General requirements applying to all solid building units.

Section III.—Building Brick

1. Size and structure: The standard size of building brick shall be 2¼x3¾x8 inches, when cured and ready for use, and for at least 90 per cent of the building brick of any lot, the linear dimension of any face shall not vary

	COMPRESSIVE STRENGTH As Laid in Wall		ABSORPTION OF MOISTURE		MODULUS OF RUPTURE			ALLOWABLE UNIT STRESS FOR MASONRY		
CLASS	Pounds per Square Inch AVERAGE Not Less Than	Allowed Deficiency for Individual Specimens Per Cent	Per Cent of Dry Weight AVERAGE Not More Than	Allowable Excess for Individual Specimens Per Cent	Pounds per Square Inch AVERAGE Not Less Than	Allowed Deficiency for Individual Specimens Per Cent	ALLOWED USE	Laid in Portland Cement Mortar	Laid in Natural Cement or Lime—Portland Cement Mortar	Laid in Lime Mortar
HARD	3500	20	16 or must pass freezing and thawing test satisfactorily	10	600	20	All exterior and interior, bearing and non-bearing walls	225	130	90
MEDIUM	2000	20	16 or must pass freezing and thawing test satisfactorily	10	450	20	All exterior and interior, bearing and non-bearing walls	170	130	90
SOFT	1000	20	No Limit	No Limit	300	20	Interior bearing and non-bearing walls. For backing in exterior walls where 4 inches or more of approved masonry protection from the weather is provided	130	130	90

Tabulated provisions of the report on solid units more than 3 per cent from this standard.

All building brick shall be rectangular in form, free from cracks and other defects which may interfere with proper laying of the brick or impair the strength or permanence of the construction.

2. Identification: All building brick shall be of distinctive design or appearance, or indelibly marked so that the identity of the manufacturer may be known.

Section IV.—Solid Building Block

1. Shape and structure of building block shall be made so as to be individually stable, and free from cracks and other defects which may interfere with proper setting or impair the strength or permanence of the construction.

2. Solid building blocks shall be of distinctive design or appearance, or indelibly marked so that the identity of the manufacturer may be known.

Section V.—Tests

1. Typical specimens of all sizes and designs of all solid building units shall be tested in an approved manner (e.g.—as recommended by the American Society for Testing Materials), to prove compliance with the requirements of this code at intervals of not more than one year. Further tests may be demanded at any time there is reasonable suspicion of non-conformance to the requirements of this code.

Report on Hollow Building Units

Section I.—Definitions

1. By clay tile is meant hollow clay or shale building units having parallel cells.

2. By concrete block is meant hollow building units, including concrete block, concrete tile and similar units, made of portland cement concrete.

3. The shell of clay tile or concrete block is the four outer walls of the unit.

4. The webs of the clay tile or concrete block are the partitions within the shell dividing the unit into cells.

5. The cells are the open or hollow spaces in a clay tile or concrete block.

6. The scoring is the grooving in the outer face of the shells made to secure bond with mortar, concrete or other covering.

> NOTE: The building terms used in this code are, in general, used as defined in the report of the Building Code Committee of the Department of Commerce.

Section II.—Clay Tile Used in Bearing and Exterior Walls

1. Weight.

The weight of hollow clay tile used in exterior or bearing walls shall be not less than the following:

CELLS VERTICAL

Dimension in Inches	No. Cells	Standard Weights
3¾x12x12	3	20
6 x12x12	6	30
8 x12x12	6	36
10 x12x12	6	42
12 x12x12	6	48
12 x12x12	9	52

CELLS HORIZONTAL

Dimension in Inches	No. Cells	Standard Weights
3¾x 5 x12	1	9
5 x 8 x12	2	16
5 x 8 x12	3	16
5 x 8 x12 (L-Shaped)	4	16
8 x 6¼x12 (T-Shaped)	4	16
8 x 8 x 8	9	18
8 x 7¾x12	6	24
8 x10¼x12 (H-Shaped)	7	32

No such individual tile shall vary more than 5 per cent under the weights given above.

> NOTE: The above tables and limit of variation is taken from the recommendations of Committee C-10 of the American Society for Testing Materials.

2. Shape and Structure.

All clay tile used in exterior or bearing walls shall be well burned and free from cracks and other defects which interfere with the proper setting of the tile, or impair the strength or permanence of the construction.

The depth of curvature or warpage of any face or web shall not exceed 3 per cent of the greatest dimension of such face or web, but in no case more than ¼ inch.

The dimensions of clay tile shall be within 3 per cent of the dimensions given in the above table of sizes and weights of standard tile.

3. Strength.

All clay tile used in exterior or bearing walls shall have an average compressive strength of not less than 700 pounds per square inch over the gross area of the bearing face when tested with cells horizontal, or 1200 pounds per square inch over the gross area when tested with cells vertical.

The average strength of any group of specimens of clay tile shall be not less than the above requirements. The strength of individual tile shall not vary more than 5 per cent below the above requirements.

Where one or more vertical faces of a tile are scored the gross area of a bearing face is determined by measuring from out to out of plain shell faces and ridges.

4. Absorption and durability.

Clay tile used in bearing walls and in walls exposed to the weather shall absorb moisture in the one-hour boiling test not to exceed 16 per cent of the dry weight of the specimen.

> NOTE: Clay tile which absorb moisture in excess of 16 per cent, but are satisfactory in all other respects, will be approved for use in bearing walls and in walls exposed to the weather, if they pass satisfactorily the freezing and thawing test as specified by the American Society for Testing Materials.

5. Branding.

All clay tile shall be branded with a distinctive indentation on the shell. Clay tile which comply with all requirements for exterior construction and bearing walls shall have the word *bearing* impressed on them.

All clay tile shall bear the name, initials or trade mark of the manufacturer.

6. Tests.

Typical specimens of all sizes and designs of clay tile used in exterior or bearing walls shall be tested in an approved manner (e.g.—as recommended by the American Society for Testing Materials), originally to prove compliance with the requirements of this code, and thereafter as directed by (proper authority).

Section III.—Concrete Block Used in Bearing and Exterior Walls

1. Strength.

All concrete block used in exterior or bearing walls shall have a compressive strength of not less than 700 pounds per square inch gross area as laid in the wall.

The average strength of any group of test specimens of concrete block shall be not less than the above requirements. The strength of individual test specimens shall not vary more than 5 per cent below the above requirements. These compressive strength values shall be developed, in a proper atmosphere, in a curing period of not more than 28 days from the date of manufacture, and thereafter there shall be no retrogression under normal atmospheric conditions.

2. Absorption of moisture and durability.

Concrete block used in walls exposed to the weather shall absorb not more than 16 pounds of water per cubic foot of concrete in the block.

3. Branding.

All concrete block used in exterior or bearing walls shall be branded with a distinctive indentation or waterproof stencilled mark, and shall bear the name, initials or trade mark of the manufacturer.

4. Tests.

Typical specimens of all sizes and designs of concrete block used in exterior or bearing walls shall be tested in an approved manner (e.g.—as recommended by the American Society for Testing Materials), originally to prove compliance with the requirements of this code, and thereafter at intervals of not more than one year. Further tests may be demanded at any time there is reasonable suspicion of non-conformance to the requirements of this code.

Section IV.—Concrete Block in Bearing and Exterior Walls

Approved clay tile and concrete block may be used in bearing and exterior walls of buildings not more than three stories, or 45 feet in height, or in panel walls in buildings of any height.

Concentrated loads shall be transmitted to clay tile or concrete block masonry by plain concrete, reinforced concrete, or solid masonry.

Where clay tile or concrete block are used in party walls there shall be not less than two such units used in making up the thickness of the wall unless solid masonry is used for building all chases, recesses, framing of all openings, and for the support, anchorage and protection of all joists and beams carried into either side of such wall.

Where a single unit of masonry does not constitute the full thickness of the wall the bonding of units shall be by masonry only. Where a brick facing, or backing, is used the bond shall consist of a full header course of brick every sixth course of brick, or equivalent. Where the facing or backing is also of clay tile, or concrete block, the bond courses shall be placed at intervals of not more than 16 inches.

Clay tile and concrete block used in bearing walls shall be well bedded in mortar. The net bearing area of all clay tile and concrete blocks as laid in the wall shall be such that the allowable unit stresses on the mortar is not exceeded.

All clay tile laid with cells vertical shall be laid in portland cement or natural cement mortar. All clay tile laid with cells horizontal and all concrete block shall be laid in cement-lime, or better, mortar.

Section V.—Clay Tile in Non-bearing Partitions

1. Weight.

The weight of hollow clay tile used in non-bearing partitions shall be not less than the following:

Dimension in Inches	No. Cells	Standard Weights
3x12x12	3	15
4x12x12	3	16
6x12x12	3	22
8x12x12	4	30
10x12x12	4	36
12x12x12	4	40

No individual tile shall vary more than 5 per cent under the weight given above.

> NOTE: The above table and limit of variation in dimensions is taken from the recommendation of Committee C-10 of the American Society for Testing Materials.

2. Shape and structure.

All hollow clay tile used in non-bearing partitions shall be well burned and reasonably free from defects which would interfere with the proper setting of the tile or impair the permanence or fire protection value of the construction.

The depth of curvature or warpage of any face shall not exceed 3 per cent of the greatest dimension of such face, but in no case more than $\frac{1}{4}$ inch.

The dimensions of hollow clay tile used in non-bearing partitions shall be within 3 per cent of the table of sizes and weights of standard partition tile.

3. Branding.

All hollow clay tile used in non-bearing partitions shall be branded with a distinctive indentation. All hollow clay tile not suitable for use in bearing and exterior walls but used in non-bearing partitions shall have the word *partition* impressed on them.

All hollow clay tile used in partition work shall bear the name, initials or trade mark of the manufacturer.

Section VI.—Concrete Block in Non-bearing Partitions

1. General requirements.

All concrete block used in non-bearing partitions shall comply with the requirements for use in bearing and exterior walls, or shall be branded with a distinctive impression to identify them for use only in non-bearing partitions.

Section VII.—Clay Tile and Concrete Block Used in Floor Construction

1. General requirements.

Where hollow clay tile or concrete block are used in concrete floor construction in a way that the whole or any portion of a tile or block is subjected to a load, the requirements which apply to tile or block used in exterior and bearing construction shall be complied with.

Where hollow clay tile or concrete block are used in concrete floor construction in a way that no portion of a tile is subjected to a load, the requirements which apply to tile used in partitions shall be complied with.

2. Branding.

All clay tile or concrete block used in floor construction shall bear the name, initials or trade mark of the manufacturer.

Repair Ancient Buddha with Cement Stucco

Modern colored cement stucco has recently been called upon to rejuvenate an ancient buddha discovered by English railway construction engineers in a British India jungle.

An excellent test of the flexible usefulness of concrete was provided on this job, since the statue, 81 ft. long and 40 ft. at its highest point, was covered by jungle growths for over a century, until discovered in 1881, when it was removed and minor repairs made by natives.

For the comfort of faithful Buddhists, the idol is enclosed in a shed of steel framework, with colored tile flooring.

(Photo by Cowling, from Ewing Galloway, N. Y.)

Stucco Cracking, Its Cause and Repair

Any form of cracking occurring in a stucco surface or slab can be classified in one of four general groups, according to the cause of such cracking. A brief description of each of these groups is given here.

Structural cracks are the largest type of crack seen and are visible some distance from the stucco surface. They generally occur in diagonal directions and are caused by a movement of the base upon which the stucco is applied. This movement may in turn be the result of settlement of the frame of the structure in having insufficient foundation area. It may be caused by warping or weaving action of the sheathing, if the house is of frame construction, or by other movement of the base. Naturally this is not a fault of the stucco and any repairs of such a type of crack would necessarily be preceded by the elimination of these structural weaknesses. The cracks may be filled by special mixtures of cementing materials, such as are produced and marketed by the Sandusky Portland Cement Company of Cleveland, Ohio, and also by the Truscon Company of Detroit, Mich. Neat or rich mixtures of portland cement have not proved entirely satisfactory for filling such cracks, due to the slight body of such a cement filler causing probable disintegration from shrinkage.

Fundamental cracking is the term given to the slightly smaller but plainly visible and usually more prevalent cracks in the stucco surface. These are usually caused by the use of wood lath which, absorbing moisture from the mortar, expands and later, on drying, contracts. These changes set up unusual stress on the stucco slab and as this is not reinforced it will not usually withstand them, and cracking results. When metal reinforcement is used, fundamental cracks may be caused by an uneven distribution of this sheet of reinforcement, in doubling up at the laps or by the sheets being insufficiently laced or tied at joints or around corners. The aim should be to provide in place of wood lath as even a sheet of metal reinforcement in the approximate center of the stucco slab, as is possible. Cracks of a fundamental type may with complete safety be repaired by filling in the manner previously suggested for treating structural cracks, since the cracking in this case is not progressive in character.

Shrinkage cracks in the slab are the most difficult to avoid. They are usually minute in size and are rarely visible without close inspection of the stucco surface. Tests have proved that fairly rapid contraction of the stucco takes place during the first ten hours, or until final set approaches. From this time on gradual shrinkage at a greatly lessened rate occurs. Curing is unquestionably beneficial in overcoming, or at least in reducing the cracking from this source. It has been shown that if appreciable shrinkage can be prevented for a few days following application by preventing too rapid drying, that the ultimate shrinkage and consequent cracking is less and that the early development of strength is helpful. Sprinkling as soon as possible after application and keeping the stucco wet for at least four days is the best method advised to properly cure the stucco. The condition under which a minimum contraction takes place before hardening is that in which the excess water in the mortar is removed by some type of absorptive backing so that stiffening occurs from this removal of water before the chemical set of the stucco takes place.

"Crazing," or minute shrinkage cracks, are the exceedingly fine cracks on the surface of the stucco, which occur in a sort of network pattern. They are unsightly, but negligibly so except in the very smooth finishes. They are the result of a mixture which is too rich or too wet, or both, as the case may be and are wholly a surface defect and do not indicate structural weakness. A wash of cement grout over the surface will generally eliminate by filling these minute cracks, provided the stucco is old enough to have developed the greater part of its total shrinkage at the time of such repairs.

Working in Cement at the Age of 102

Fellow-workers in cement, meet the oldest member of the craft—Jonathan Begg of Pasadena, Calif., born in Aberdeen, Scotland, in the spring of 1824!

For all of his 102 years—"No, my friend, 101 and two-thirds years," he insisted—he is busy all day long, either dabbling in concrete mixtures or writing on his book (assisted by a secretary), or trying to interest people in his community-building plans, or walking for his health.

"I went twenty-four blocks yesterday," he told me proudly as we descended the two long flights of stairs from his hotel room. "I like walking, but my book worries me. You see, my hands are too unsteady for writing, though I can read quite a little without glasses. You want me to show you my invention? All right we—no, I won't, either! It isn't patented and you might copy it!" he cried cannily. "But I will tell you this: my process makes building of concrete cheaper than with wood, largely because it is so quickly done that little labor is used. My walls are poured at one time, the interior and exterior finishes being done simultaneously, a finer grade being used inside, the coarser, reinforced material forming the outside, though all poured at once. When I get my patents through I can tell you plainer."

The old man's pet hobby, however, is his community housing plan, which groups the quickly built houses in a court with community kitchens and living rooms with special comforts and labor-saving devices that cannot be had in cheap quarters. A special heating and cooling apparatus common to the entire group are of his own devising and thoroughly practicable. Each of the units or family sections would have four private rooms and a large sleeping porch, and these he wants sold at cost plus 10 per cent profit to the builders.

Mr. Begg claims to have twenty-five successful inventions to his credit, only two of which, however, have brought him much money. He declares he prefers working with cement "because it is one of our most useful materials and most lasting."

Inundation Method for Constant Concrete

The inundation method for supplying the correct amount of water in the concrete batch has been discussed at various times in the past, particularly at the last convention of the American Concrete Institute, and considerable information has been presented in the various articles on the subject. Many of the important points are summed up in a paper prepared by the Blaw-Knox Co. under the heading "The Blaw-Knox Inundation Method," which describes the practical application of the method to the concrete construction job in general, and from which the following excerpts are taken.

The subject of better concrete is of vital importance, not only to those directly interested in its use, but also to those engaged in the production of each of its component parts. Constant concrete may be defined as a concrete the properties of which are so uniform in quality and strength that it may be considered as possessing all of the good attributes of an unvarying material.

The Bulking Action of Moist Sand and Its Effect Upon Concrete

The characteristics of the fine aggregate—Sand—as received in the field, are such as to make the accurate and consistent measuring of sand and water impossible with the devices used up to the present time, for the reason that the sand is always more or less damp:

First, a varying amount of water is introduced by the sand into the mixer and the total amount of water introduced from batch to batch varies in direct proportion to the amount of moisture held in the sand. This total amount is sufficient to considerably weaken the concrete unless compensated for.

The Blaw-Knox Inundator used by the Turner Construction Co. on the Pitt Stadium, Pittsburgh, Pa.

Second, sand cannot be accurately measured by any device which does not compensate or correct for the bulking or fluffing of the moist sand. This bulking may result in variations of as much as 40% in the absolute amount of sand held in a given volume.

The fact that specifications are drawn with dry sand in mind and fulfilled with the use of wet or moist sand, is a daily happening in the making of concrete. Realization of what actually occurs when the sand is wet or moist, as compared with the resultant yield of concrete when the sand is measured dry, is startling, to say the least.

If specifications call for a certain number of cubic feet of sand in the mix which is based on dry sand, and if the contractor actually uses moist sand (which he does), he will use, by the same bulk measurement, 15 to 40% less sand in each batch than the specifications call for. Naturally, when the sand is mixed with stone, cement and water, the yield of the concrete will be from 3 to 10% less than it should be, all because the sand has been measured in a moistened and swelled condition, instead of bone dry.

This is not the only lack of uniformity in the concrete. Because there is less sand used for the amount of stone specified, there will be incompletely filled voids, which means unsound concrete. due to insufficient mortar. Because the yield is less than it should be for the theoretical amount of material used, the contractor is obliged to make more batches for a specified quantity of concrete poured, which means a loss of time over and above his estimate for the job.

Just as important, if not more so, is the question of automatic control of the volume of mixing water used in the batch.

Since it is seen that a variation of only a few percent, more or less of water has an enormous influence in the strength of concrete, it will be apparent that constant results cannot be obtained without a method for correcting not only the bulking of sand, but also the water carried by the sand. The problem then is one of finding a means of measuring the water and the sand whereby the amount of water and sand in a given volume will be known and constant quantity for successive batches under all moisture conditions of the sand.

What the Blaw-Knox Inundation Method Is

The Blaw-Knox Co. has introduced the Inundation Method as a practical solution for the bulking of sand. It is based on the principle that when sand, regardless of the degree of dampness which it contains, is submerged or inundated, the bulking effect due to such dampness ceases, and the sand settles to a uniform compactness in the water. Once the sand is thus inundated, the amount of water held by the sand previous to its inundation is of no further importance. The voids of the sand are filled. This amount is constant and cannot vary.

The Blaw-Knox Inundation Method consists of an inundator or self-dumping and righting steel container with an adjustable bottom, a shaker or sand sifter, a strike off gate and an excess water measuring tank and water storage chamber.

The Inundator is mounted on a trunnion arrangement, so designed that in a single movement the sand and the water for the mix are deposited in the mixer hopper. The specified batch of stone or gravel is placed in the hopper by means of a batcher, or other measuring device, and the cement is introduced in the batch in the customary manner.

How the Inundator Supplies Correct Amount of Water to Batch

When it is remembered what effect the variation of only a few per cent, more or less, has on the strength of concrete, it will be apparent that constant results cannot be obtained without finding a method for correcting not only the bulking of sand, but also the water carried by it. Thus, it is clearly shown that, in addition to compensating for the moisture or lack of moisture in sand, the further demands of constant concrete are that an equal and exactly measured amount of water be placed in each batch. In the Blaw-Knox Inundation Method this is provided for.

An excess water measuring tank for the purpose of storing additional water for the batch is incorporated in the Inundator. This functions as follows: The exact amount of water necessary to inundate a specified amount of sand is a known quantity, that is the amount necessary to fill the voids in the measured sand which is insufficient for the batch itself. The excess water tank is therefore used to measure for each batch sufficient additional water to complete the batch. Thus, we have the two variable elements adjusted to a nicety—one, an exact measure of sand; two, exactly the right quantity of water, both as are specified by the engineer for the manufacture of the best possible concrete for the particular job.

It is repeated that, in specifying the Blaw-Knox Inundation Method, the engineer automatically makes sure that the carefully worked out formulas he has determined as being the best for the structure under consideration will be absolutely followed, that all possible chances for variation in the concrete, due to the bulking action of sand and measurement of water, which have hitherto been uncontrollable factors, will no longer exist; that he is imposing no hardship on the contractor because the addition of the Inundation Method to the contractor's equipment is small, permanent, and represents a direct economy in its use.

Crazing—The Universal Problem Yet a Mystery

By HARVEY WHIPPLE

Some times there is heard a note of impatience, that our technical leaders don't hurry up and tell us all about the whys and wherefors of crazing or map-checking and give us an unfailing remedy. It is probable that there are more people in the concrete industry who want that information than who are interested in the solution of any other single problem.

It is not clear that crazing, as usually encountered, does any harm, except as in some instances it becomes a blemish in appearances.

A few say they have solved the problem. If it is true that the worst thing that can be said of crazing is that it is an affront to the eye on an otherwise attractive surface, then perhaps they have solved it. In some cases it takes a magnifying glass to see it. In that case it doesn't exist to the naked eye; so, as there is no affront, perhaps the problem is solved.

It is generally agreed that fine surface materials induce crazing; that troweling, in bringing fine material to the surface, aggravates it; that rapid, dry curing augments it. Some say it is in the nature of the cement to craze and that lean mixtures do not craze. It is argued, too, that in making concrete of exceptionally high quality, where that high quality is equal throughout a given surface area, no crazing is apparent. Others harp on that word "apparent" and insist that, because of the evenness of the surface quality, the shrinkage is everywhere equal and that the surface, instead of opening in a few checks which are visible, opens in a multitude of checks so small they can't be seen.

It is not the presumption here to tell what causes crazing and how to remove the cause. That is left for others to do after the interest in the subject has become great enough to impel the interested persons to foot the bill for the necessary investigative work which will probably be necessary before the answer is found.

Dr. P. H. Bates, of the United States Bureau of Standards, who is chairman of the American Concrete Institute's Committee on Crazing, has pointed out that a voluntary committee can do some worthwhile work around the edges of the subject but real results are not likely to come until some painstaking investigator has spent a long time at tests and experimental work. That sort of thing costs money. When knowledge of crazing has a money value put on it—and it ought now to have that money value, judging from the general interest in the matter among men who encounter the problem in the enterprises by which they live—we may find the answer.

In the meantime there is this wisp of comfort: The concrete industry is not alone with the problem. Those who grow impatient, supposing perhaps that crazing is a phenomena peculiar to concrete, will be interested in the fact that crazing is a very general phenomena. It is as common as dirt—literally so, as anyone can see for himself in occasional puddles of fine mud, drying out under a summer sun. As the mud dries out on the surface, crazing is commonly seen. Many natural building stones craze. Varnish manufacturers have studied crazing and not with complete success either. Probably a long list of materials might be made, which, under certain conditions, develop a kind of skin tension which is relieved by minute cracks. The problem is not uncommon in the ceramic industry, as many household dishes will show and certain lines of pottery have their note of special attraction in their crazed surfaces.

In still another industry, a quite different industry, which we are not at liberty to mention specifically because of certain confidential sources of information, we get the other side of the picture. A product of this industry, manufactured abroad, gets a certain aesthetic quality from the fact it has a close pattern of surface crazing. An American manufacturer, recognizing that attractive quality, is trying to find out how to produce crazing in the material which he makes in this country. He is more anxious to know how to produce crazing than most of the concrete people are to know how to prevent it. He is spending money to learn the trick which the foreign manufacturer knows and is taking advantage of.

So if we don't know how to prevent crazing, neither do we know how to cause it dependably. The answer to either problem will probably solve the other.

Most of the crazing experienced in the manufacture of cast stone occurs in the units that simulate Bedford stone, and little occurs in the artificial granites. For that reason, and for others, trim stone manufacturers are discouraging the use of the man-made limestone. Others resort to cutting the stone after it has hardened.

Highway Bridge Has New Lighting System

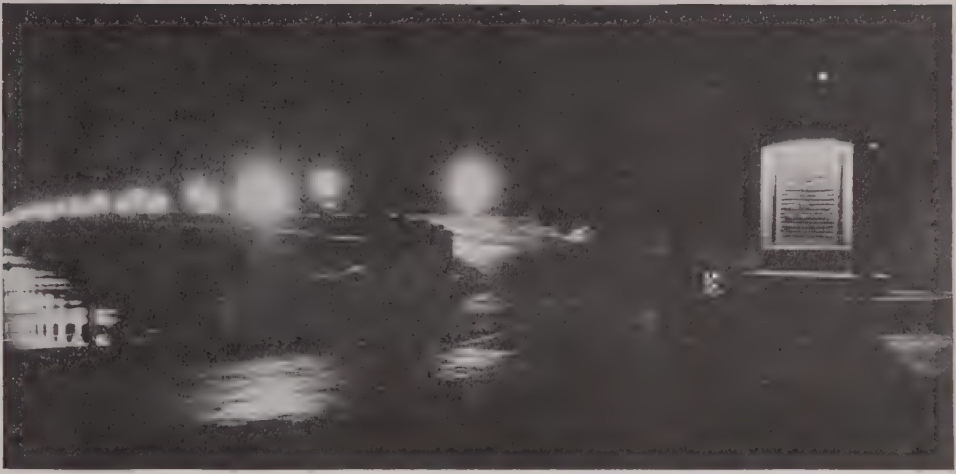


Fig. 1—The Clark's Ferry bridge at night, showing the extent of illumination by the special Westinghouse lanterns

Unique features of the new Clark's Ferry bridge which was opened to traffic in August, near Harrisburgh, Pa., include wide curved approaches and bright illumination at night by powerful electric lights. The accompanying illustration of a night view of the bridge shows the lights reflected in the water of the Susquehanna River, and the lights are powerful enough to faintly illuminate the nearby hills.

Some interesting history centers around the site of the present modern reinforced concrete bridge structure. A span of 137 years has lapsed since Daniel Clark, a sturdy pioneer in 1788, founded at this spot what subsequently became known as Clark's Ferry where travelers could cross the river even at night with the aid of primitive torches.

In the place of the old ferry stands the new concrete bridge, the structure having a total span of approximately one-half mile and a roadway 20 ft. wide capable of carrying two lines of the heaviest modern traffic. Even with the time consumed by the collection of tolls, it is estimated that the bridge can easily handle 18,000 cars a day if necessary.

The design and supervision of the structure were by Frank Milton Masters of Harrisburg with Ralph Modjeski, chief engineer of the Delaware River bridge, as consultant, and Prof. Paul P. Cret, University of Pennsylvania, as consulting architect.

Particular stress in the design of the bridge structure was laid upon the ornamentation of the roadway. At the suggestion of the State Art Commission, provision was made for a layout of light standards which were designed by Prof. Cret, and Westinghouse engineers were commissioned to execute the work. A special Westinghouse lantern was adopted and incorporated in the design of each of the light bases for the respective arches and abutments at the bridge approaches.

A One Year Job

Construction of the bridge began in June, 1924, and was completed last June, in one week less than a year's time. The work was done by the Vang Construction Co., Cumberland, Md. Immediately afterward Westinghouse engineers began installing the illuminating fixtures, completing the job in August. For the present 12,000 watts will be required to illuminate the bridge and approaches. This amount of current will provide sufficient light to permit automobiles to readily cross the bridge with headlights shut off. Incidentally, the new bridge, supplanting the old covered structure built 97 years ago and now being torn down will carry the traffic of two national highway systems, the Susquehanna Trail and the William Penn Highway.

The earliest means of transportation over the Susquehanna River near this location was the ferry owned and operated by Robert Clark, son of Daniel Clark. In 1828 and 1829 the Commonwealth of Pennsylvania replaced the ferry with a dam and a highway toll bridge, supporting a towing path, which was constructed and operated as a part of the State's Canal System, for the purpose of transporting canal boats across the river.

In 1857 the Commonwealth of Pennsylvania sold its entire canal system to the Pennsylvania Railroad Co., which company in 1887 organized and transferred this property to the Pennsylvania Canal Co., operated as a part of the Pennsylvania Railroad Transportation System. In 1915 the Pennsylvania Canal Co., having abandoned the canal operation, then entirely replaced by the railroad system, sold the bridge to the present owners, the Clark's Ferry Bridge Co.

Contractors are learning that a small extra expenditure for carpenter work will have a lot of money on patching of set concrete and on refitting trim stone. Some go so far as to erect forms that look like a permanent decorative job, and say that it pays. Again we see the builder who uses the cheapest grade of lumber, boards that cannot well be fitted even with extra labor, and who has these boards thrown into place any way, and who still expects to really save money. This contractor is always surprised when he has to spend extra money on chipping off fins, patching honeycombed slabs, and on leveling up girders so that trim can be laid. He has paid more because he tried to save on carpenter work.

A neat, strong, and efficient set of forms is a worthwhile investment on any work. It saves money in the long run.

Predicting the 28-Day Tensile Strength

A Study of the 7-Day and 28-Day Tensile Strength of Portland Cement

By M. A. DURLAND
Assoc. Prof. Machine Design, Kan. State Ag. Col.

A careful study of recent technical literature does not reveal any thorough investigation of the variation in tensile strength of cement samples made up with standard Ottawa sand, or the relation between the 7-day and the 28-day strength of these same Ottawa sand briquettes.

In general there is a fairly definite increase in strength in these briquettes and therefore a certain relation between the 7-day and the 28-day strengths. This can only be determined by a statistical analysis of a large number of samples.

During the past six years, more than 8000 cement samples (each sample consists of three briquettes) have been tested by the Road Materials Laboratory at the Kansas State Agricultural College. This is the official laboratory for testing Kansas highway materials, so that the greater part of the tests have been made for that purpose. Some of these tests have been made at the laboratory and some at the cement plants by men from the laboratory.

Scope of Tests

The comparatively long period of time covered by these tests, and also the fact that eight different brands of cement (six from Kansas, one from Missouri and one from Oklahoma) are included, some of which are made by the wet and some by the dry process, contribute to making the results quite general.

There are many factors which affect both the variability of the tensile strength and also possibly the rate of increase, but it is thought that practically all of them are included in these tests. It will be shown later that the rate of increase in strength is practically independent of the 7-day strength.

None of the brands included in this investigation had less than 600 samples so that all the numbers used are sufficiently large to justify a statistical analysis. In order to apply the usual statistical methods it is necessary that the data form a normal distribution. This is true in this case as is shown by Figs. 1 and 2. These figures give the distributions by 20-pound intervals for the 7-day and the 28-day tensile strengths respectively, for 8109 samples. Superimposed upon each of these histograms is the normal probability curve based upon the maximum ordinate, mean and standard deviation of the sample. The fit of the curve is all that could be expected in Fig. 1 but slightly skewed in Fig. 2. It is not thought that this skewness is marked enough to make the constants derived very greatly in error.

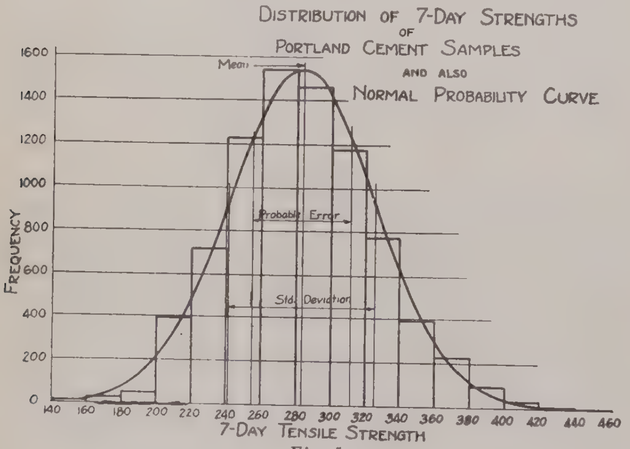


Fig. 1

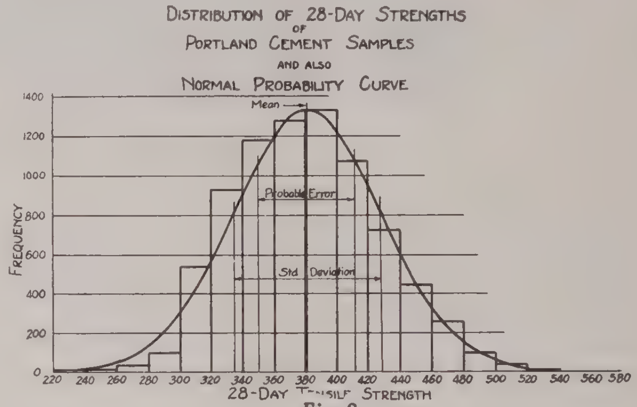


Fig. 2

Probability of Error

The correlation coefficient used throughout is that of Pearson given by the formula

$$r = \frac{\Sigma xy}{N\vartheta_x\vartheta_y}$$

Where x and y are the distances from the mean and ϑ_x and ϑ_y the standard deviations and N the number of samples.

The relation between x and y and between y and x is shown by the regression lines which pass through the mean and whose slopes are given by the formulas

$$\frac{x}{\vartheta_x} = r\frac{y}{\vartheta_y} \text{ for the regression of } y \text{ on } x \text{ and}$$

$$\frac{y}{\vartheta_y} = r\frac{x}{\vartheta_x} \text{ for the regression of } x \text{ on } y.$$

The equation for these lines would then be

$$x = Mx - r\frac{\vartheta_x}{\vartheta_y}My + r\frac{\vartheta_x}{\vartheta_y}y \text{ and } y = My - r\frac{\vartheta_y}{\vartheta_x}Mx + \frac{\vartheta_y}{\vartheta_x}x$$

Mx and My are the means.

Figure 3 is the complete correlation chart for 8109 samples and shows the results including both of the regression lines. The dotted lines drawn through the means of the columns and rows represent the raw regressions and the solid ones those computed from the equations given above. It is important to note that between the limits of 200 and 400 pounds for the 7-day tensile strength the calculated regression line ($y = 169 + 0.75x$) is practically identical with the raw regression line; and also between the limits of 300 and 500 pounds for the 28-day strength the calculated regression of x on y follows the raw regression line very closely.

Whether or not this relation is linear is of considerable importance so that a mathematical investigation of the question should be made. This can be done by means of the correlation ratio, "*Eta.*"

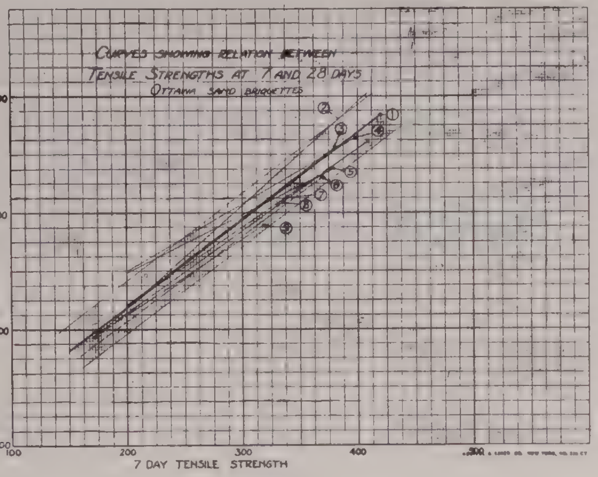


Fig. 3

"*Eta,*" the correlation ratio, is the root mean square deviation of the means of each array about the mean of the whole distribution and is the limiting value of "*r*," the correlation coefficient. The correlation coefficient is necessarily smaller than "*eta*" (η) but approaches it as a limit when the relation between the two variables is perfectly linear. The departure of the true regression from the regression line calculated from the equation $\frac{x}{\vartheta_x} = r\frac{y}{\vartheta_y}$ is usually measured by the quantity $\eta^2 - r^2$, which is the mean deviation of the actual regression line from a straight line. Some difference in the value of "*eta*" and "*r*" is to be expected in any finite distribution but the relation between the quantity $\eta^2 - r^2$ and its probable error gives a basis for judging as to whether the difference is a random one or not. Blakeman gives the standard error of $\eta^2 - r^2$ as $\frac{2}{\sqrt{N}}[\eta^2 - r^2]^{1/2}$. The equation for the ratio is then

$$\frac{\eta^2 - r^2}{\text{Prob. error of } (\eta^2 - r^2)} = \frac{\sqrt{N}}{.6745} \times \frac{1}{2}[\eta^2 - r^2]^{1/2}$$

If this value is greater than 2.5 or 3 it is probable that some curve would fit the distribution better than a straight line (if a difference is three times its probable error, its likelihood in a random sample is 4 in one hundred).

Referring to Fig. 3, the value of $\eta^2_{xy} - r^2$ is only 1.36 times its probable error, which certainly does not represent a significant departure from a straight line. However, the value of $\eta^2_{xy} - r^2$ is 3.01 times its probable error, which probably indicates a slight departure from a straight line. However, it appears from the raw curve that the variation is concentrated at the extreme ends so that it is thought that the straight line shown is the best fit for the actual results.

Use of Charts

The sample illustrated in Fig. 3 is made up of eight different brands of cement each of which may be treated in the same manner that the composite sample has been. The best means for studying these samples is by means of their regression lines. These show the most probable value of the 28-day strength for any given 7-day strength

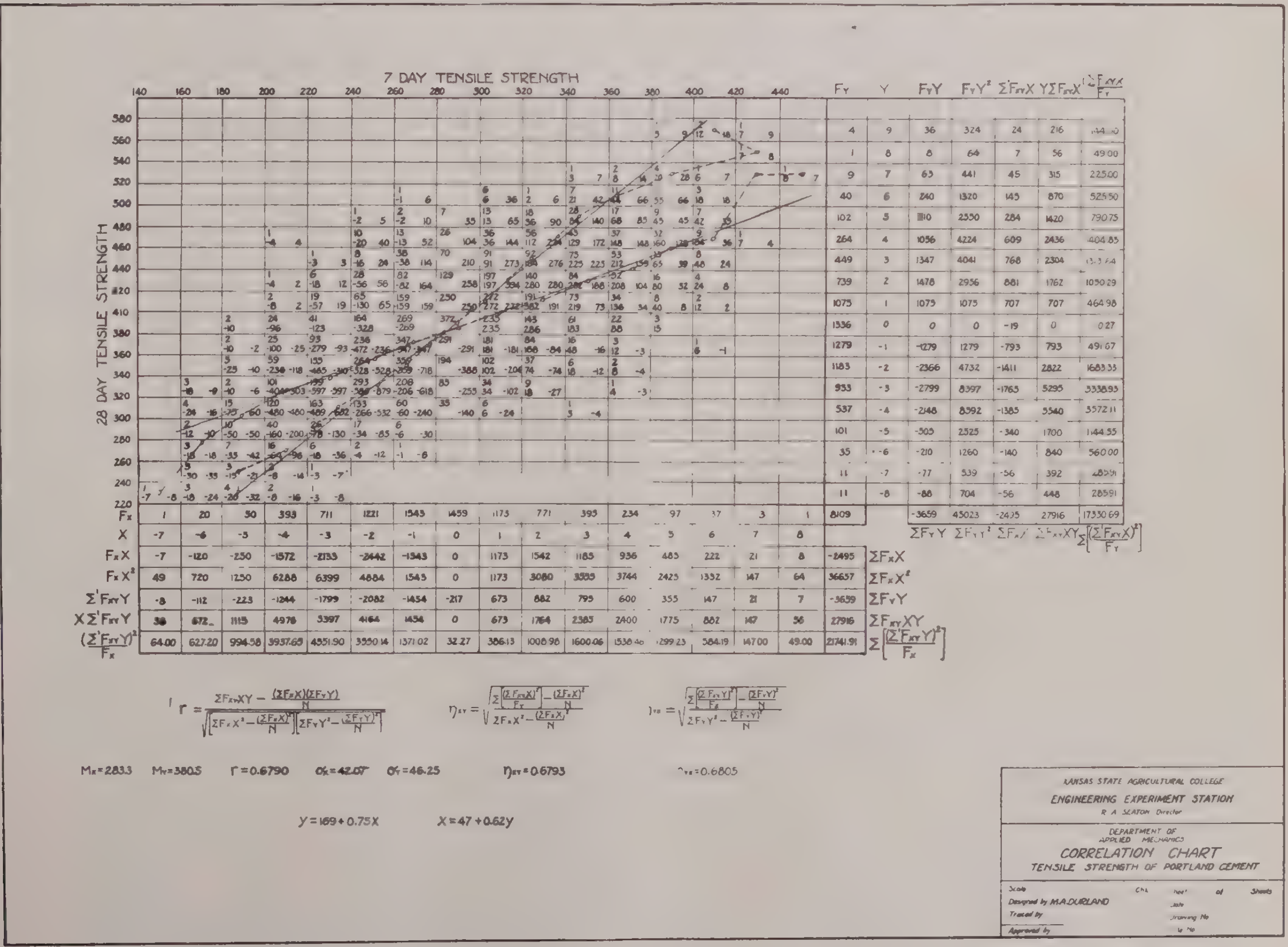


Fig. 4

and also the rate of increase in strength.

Figure 4 shows the regression lines of y on x for these eight different brands of cement and also for the composite sample. The equations of the lines shown are given below as derived from the general equation

$$y = My - r\frac{\vartheta_y}{\vartheta_x}Mx + r\frac{\vartheta_y}{\vartheta_x}x$$

1. $y = 169 + 0.75x$ (Composite sample)
3. $y = 171 + 0.75x$
2. $y = 139 + 0.89x$
6. $y = 161 + 0.73x$
7. $y = 172 + 0.71x$
8. $y = 187 + 0.67x$
9. $y = 182 + 0.65x$
5. $y = 249 + 0.50x$
4. $y = 236 + 0.57x$

The lengths of the lines shown in the figure indicate approximately the range of the distribution of the sample. The values of the means vary from 251 to 310 for the 7-day tests and from 345 to 408 for the 28-day tests. However, this apparently has very little effect on the rate at which the cement increases in strength as shown by the closeness of the grouping of the curves.

Example

The shaded area in Fig. 4 which extends an equal distance on each side of the mean regression line is the limit of probable error of y as predicted from any value of x in the equation $y = 169 + 0.75x$ and is computed from Probable Error of $y = .6745\,\vartheta_y\sqrt{1 - r^2}$

This gives in this particular case ± 23 pounds. In other words, having given the 7-day strength of a cement sample the value of the 28-day strength may be predicted within 23 pounds on the average. Applying this to a particular case, assume the 7-day strength of a given sample to be 280 pounds, the 28-day strength from the equation (or from the curve) would be 379 pounds. In order to pass the standard specifications the 28-day strength must be not less than 300 pounds. The difference between this value and the predicted value is 79 pounds, which is 3.43 times the probable error. From the probability curve it is found that the likelihood of an error in prediction of 3.43 times its probable error and in one certain direction is about one in 100. Therefore, the chances are 100 to 1 that a sample having a 7-day strength of 280 pounds per square inch will pass the 28-day requirement.

Some of the variation in rate of increase in strength as well as the variation in actual strength is due to the operator who makes up the briquettes and to a lesser degree the results may be affected by the one who breaks the briquettes. From the consideration of this and in the light of the results shown it would seem that cement briquettes made up with a 1:3 Ottawa sand mix have a much more definite rate of increase in tensile strength than has generally been supposed.

Quicker Hardening to Speed Work

Work May Be Speeded Up by the Proper Methods of Making Concrete—High Early Strength Concrete May Be Secured by Any Contractor with Standard Portland Cement—Principles to Be Followed—Use of Admixture —Special Cements

By KENDRICK A. HATT

The owner of today is often impatient for the completion of his structure. Rents must start coming in at the earliest possible moment. On paving and bridge work it is often necessary to turn the traffic back upon the improved route within the shortest possible time. Cold weather work has risks that may be minimized by getting concrete to harden more rapidly. Under such conditions the normal setting of ordinary concrete causes inconveniences and special provisions for a speedy completion of the work are desirable. On small housing the work may be rushed by the use of precast units, and this plan has even been used with success on massive railroad construction, but this solution is not always applicable.

On monolithic concrete work there are but three alternatives—the use of special methods of mixing and placing concrete in which standard portland cement is used, the use of a commercial accelerator, or the use of special cements. Investigators have now demonstrated that high early strength concrete can be secured with ordinary portland cement, provided that certain principles are followed. These may be summed up as:

Decreasing the amount of mixing water,
Using a richer mixer,
Increasing the mixing time,
Increasing the temperature of the mix,
Curing under a higher temperature,
Affording sufficient moisture during the curing period,
Using a little calcium chloride or other good commercial accelerator where advantageous.

Quantity of Mixing Water

It is a well-known fact that the quantity of mixing water has a direct and important effect upon the strength of concrete. This matter has been discussed time and again in the pages of this journal, in other technical construction journals, and at the meetings of the American Concrete Institute. An increase of about 1 per cent of water, for ordinary mixes, results in strength reductions at one and two days of about 5 per cent. Figure I illustrates this principle.

This effect of the quantity of mixing water on the strength of concrete has been so definitely determined that concrete work is now being pursued with little but a water-cement ratio strength specification to govern the man at the mixer. Thus the quantity of mixing water must be restricted to the minimum that will produce a plastice mix if concrete of a high early strength is desired. Reducing the amount of mixing water increases the strength at 28 days, and therefore increases the strength materially at 3 days. Take, for instance, the 1:2½:4 mix mentioned in Fig. 2. This concrete, with 7.7 gallons of water per sack of cement, produces a strength of about 2600 pounds at 28 days and of 750 pounds at 3 days. If the water content of this same batch is reduced to 6.1 gallons of water per sack of cement, the strength at 28 days will be 3700 pounds, and the three-day strength will have been increased to 1350 pounds. Many contractors have found that hydrated lime will give the necessary increased workability and thus make possible the use of a smaller quantity of mixing water, and thereby give concrete a higher strength.

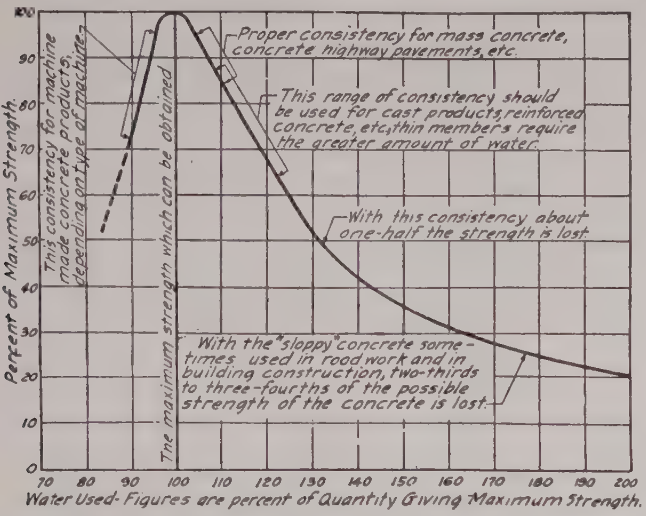


Fig. 1. This chart, published through the courtesy of the Structural Materials Research Laboratory, Chicago, shows the relationship between water-content and the strength of concrete. The less the water the greater the strength until mixes too dry to work are reached

	Mix	Bbls. Cement Per Cu. Yd. of Concrete	Gallons Water Per Sack of Cement	Approx. Slump. Inches	Lbs. CaC1₂ Per Sack Cement	Minutes Mixing Time	Compressive Strengths Pounds Per Square Inch			
							1 Day	3 Days	7 Days	28 Days
A	1.2½:4	1 4	7.7	6 to 7	0	1	240	750	1320	**2600**
B	1:2½:4	1 4	7 7	6 to 7	0	5	340	910	1550	3030
C	1:2½:4	1 4	6.1	½ to 1	0	1	520	1350	2090	3700
D	1:1½:2½	2.1	5 5	6 to 7	0	1	560	1580	2530	4230
E	1:1½:2½	2.1	4.4	½ to 1	0	1	880	**2410**	3630	5250
F	1:1½:2½	2.1	4.4	1	0	5	1150	2860	4020	5740
G	1:1½:2½	2.1	5.5	6 to 7	2	1	930	1880	2610	3800
H	1:1½:2½	2.1	3.4	0 (Dry)	2	5	1910	3380	4200	5260
U	1:1¼:2½	2.25	4 6	½ to 1	0	5	1580	(Concrete used in road at U. P. C. Co.)		

Fig. 2. This interesting tabulation, compiled for Universal Portland cement, shows how high early strengths may be obtained by various means, as outlined on this page. By courtesy of the Universal Portland Cement Company

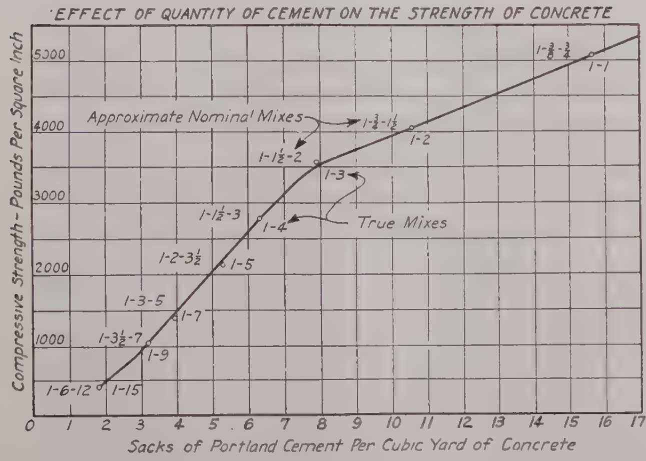


Fig. 3. Chart showing effect of quantity of cement on the strength of concrete

Richer Mix

If the quantity of cement is increased 1 per cent the 28-day strength will be increased by a like amount. Tests reported in Bulletin 4 of the Structural Materials Research Laboratory show this increase to be somewhat greater at the earliest ages. If the same 1:2½:4 batch shown in Fig. 2 be changed to a 1:1½:2½ mix, and 5.5 gallons of water be used to give the 6-7-inch slump secured with the former mix, then the 28-day strength will be 4230 pounds, and the three-day strength will be 1580 pounds. Rich mixtures are necessary if high strengths are desired at 3 days.

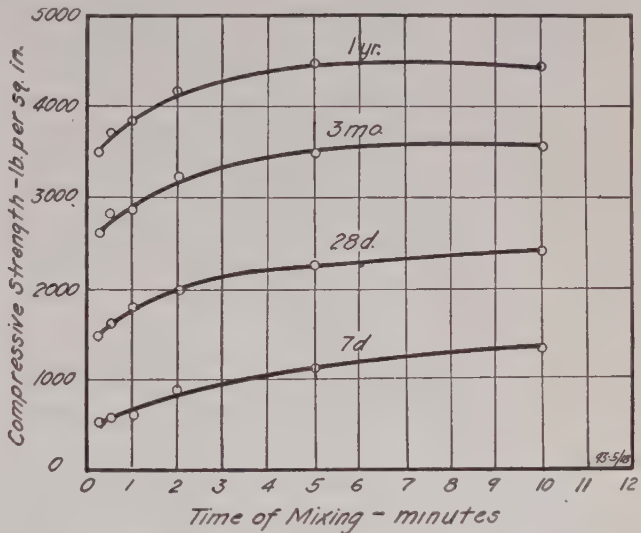


Fig. 4. Chart showing effect of length of mixing time on the strength of concrete

Longer Mixing Time

Since rich and dry mixtures are required for high early strengths, it is necessary to devote greater attention to mixing than when the more normal strengths are sufficient. The influence of increased mixing time is more pronounced with these richer and drier mixes. Take, for example, the 1:2½:4 mix giving the 28-day strength of 2600 pounds and a three-day strength of 750 pounds, with a one-minute mix. Increase this mixing time to 5 minutes and the 28-day strength becomes 3030 pounds and the three-day strength has been increased to 910 pounds.

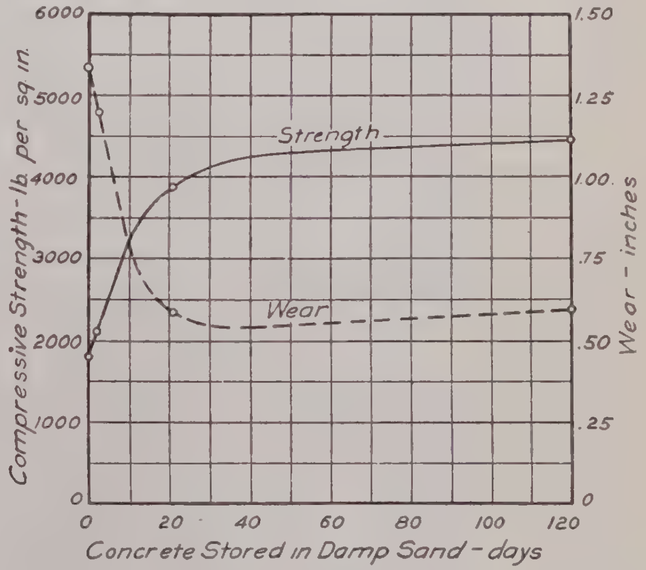


Fig. 5. Chart showing effect of time of curing on the strength of concrete

Other Factors Important

It is a well-known fact that the use of a coarser aggregate will lead to some increase in strength, within certain limits, and this is thought to be due to the fact that less water is then required for the same workability. Curing conditions, especially in winter, are of great importance. In cold weather the aggregates and the water must be heated, and high early strengths cannot be obtained unless the temperature of the work is at least 70 degrees Fahrenheit, and the correct amount of moisture is present.

Chemical Admixtures

Investigation has shown that, with many brands of cement, the use of a small amount of calcium chloride, or other good commercial accelerator, will often lead to a more rapid hardening of the concrete. Certain precautions, however, are considered to be advisable if admixtures of this type are to be used. It is necessary to know just what the admixtures will do when used with the particular brand of cement that will be found on the job. It has been observed that some cements do not react to a particular accelerator, some respond but slightly, others react quite favorably, and sometimes the admixture will cause a flash set when the wrong amount is used. It must be kept in mind that the increase in strength from such materials is only relative. If air temperatures are such that plain concrete cannot be expected to attain any more than a fraction of the required strength, then the use of accelerators cannot be expected to perform alone the miracle of saving the job. When used as intended, however, they will be found to be very useful. In freezing weather the use of such an admixture does not eliminate the necessity for using other precautionary measures, but when used in conjunction with other measures, it ordinarily helps to give the needed strength to the concrete.

Making the Solution

The successful use of calcium chloride as an admixture depends to a great extent upon the quantity used. Generally two pounds of calcium chloride per sack of cement has been found to be a satisfactory amount. This amount can best be added as a standard solution that may be prepared as follows: Fill a 50-gallon barrel about two-thirds full of water and put in 100 pounds of commercial flake calcium chloride. Stir until the chloride is all dissolved, then fill the barrel with water. This produces 50 gallons of the standard solution with two pounds of the chloride in a gallon, or ½ pound in a quart. Mix the batch of concrete in the usual way, except that for each sack of cement used substitute in the mixing water one gallon of the solution from the barrel for one gallon of the water.

It may be observed (as shown in Fig. 2) that when 2 pounds of calcium chloride per sack of cement were added to a 1:1½:2½ batch, requiring 5.5 gallons of water per sack and mixed one minute, that the 3-day strength was increased from 1580 to 1880 pounds. With the cement used, however, the 28-day strength was higher in the batch in which the chloride was not used. The influence of the calcium chloride admixture is apt to differ with each brand of cement, so it is safest to be guided by tests when using the admixture.

In summing up, it is easy to obtain, with a standard portland cement, concrete that is fairly workable, a 3-day strength concrete that is high enough for ordinary purposes. Less water, a five-minute mix, carefully graded aggregates, a high cement factor, and favorable curing conditions will ordinarily do the work.

It is remarkable that the various brands of cement are as uniform as they actually are. They all pass certain standard minimum requirements and by using the methods described above high early strengths can be obtained in concrete made from any standard brand of portland cement.

Nevertheless, concrete made with some brands of cement will attain higher early strengths than concrete made with other brands. There are some portland cements on the market today that will produce early strengths very nearly approaching those of special cements. These, of course, are often preferred when high early strength concrete is sought. But too much reliance must not be placed on the quick-hardening properties of these cements. The requirements for making good concrete previously enumerated must be adhered to if satisfactory results are to be assured.

Special Cements

There are several special cements now available for the convenience of the contractor who prefers their use to standard portland cements as outlined above. Until very recently all of these special cements had to be imported from Europe, where the problem received earlier attention. Some of these special cements are still coming in, but at least two are already being produced in the United States.

The first special cement to be manufactured in this country, to meet the demand for a cement that would give high early strengths, is the high alumina cement known as Atlas Lumnite. This cement, manufactured under the Spackman patents, is able to give a concrete that will have compressive strengths in 24 hours that equal the strength of ordinary portland cement concrete in 28 days. High alumina cements have not been under observation for a long enough time for their behavior over a period of years to be fully known.

A special portland cement, known as Super-cement, is now being made by two cement mills in North America. This cement, too, should prove to be of value on the job.

Recent reports from France tell of a quick-hardening portland cement that is made from raw materials readily available and at a considerable saving in cost as compared with the French high alumina cements, the bauxite for which has to be transported a considerable distance. It is claimed for this cement that concrete in which it is used hardens in a shorter time than the high alumina cement concrete.

It is now possible, as explained herein, for the contractor who does any kind of concrete work, to so use standard portland cement, special cements, or admixtures, that his contract may be available to use in far less than the usual time. For all ordinary purposes the correct manipulation of standard portland cement will give a high early strength. For unusual requirements where 28-day strength must be scured in a few days, it is quite possible to use special cements in place of the portland. The methods described enable any contractor to speed up the completion of his job and they assure the making of a high quality of concrete.

A New Use for Concrete

It's not only the great bank vaults that use concrete to foil the attacks of the ever-present criminal intent on raiding the funds intrusted to their care. The Ehrlich Safe and Lock Company, Chicago, have now devised a small safe, for use in filling stations and other places, that depends upon concrete for a great part of its security. This safe consists of a steel cylinder provided with a special lock, and mounted on a steel tube. This steel tube is imbedded in concrete, and is filled with concrete, holding the safe secure against removal. The safe is opened only by the collector, no key being available at the station. It is said that this combination of concrete and steel affords maximum protection for the amounts normally handled in such a business. The concrete work in connection with the installation of the safe is done on the job, according to specifications and directions furnished by the manufacturer.

Concrete in Architecture

Wilshire Boulevard Congregational Church, Los Angeles, an Example of Possibilities—Original Texture of Walls Retained—Ornamental Features Cast in Place

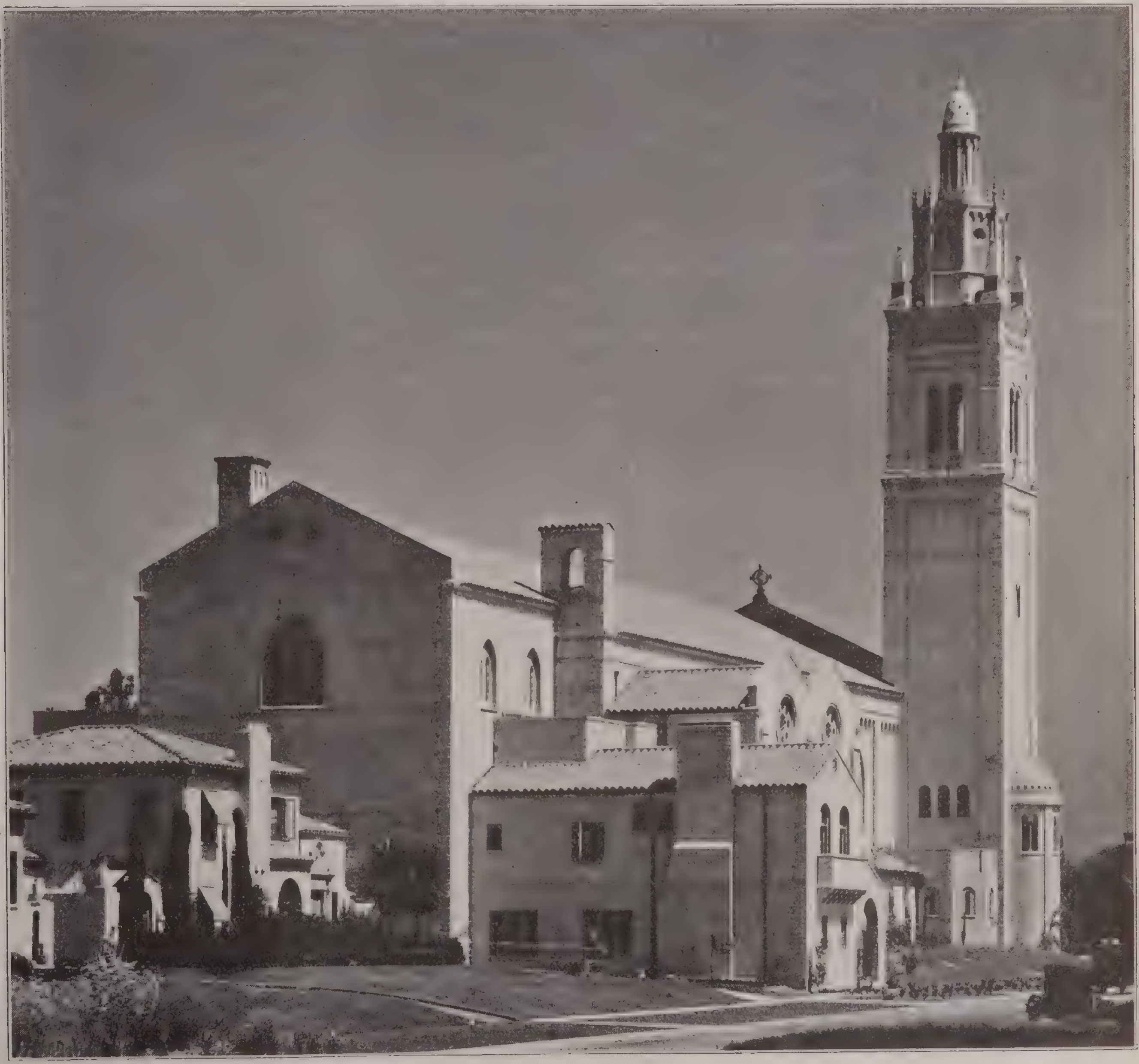
Los Angeles comes to the fore with some outstanding examples of fine structures of monolithic concrete. One of these is the beautiful Wilshire Boulevard Congregational Church, illustrated on this page. Allison & Allison of Los Angeles are the architects.

In casting the concrete for this job, considerable care was exercised in securing straight, true form work of shiplap lumber, all running horizontally, with a thought to the impression left in the concrete after stripping. The concrete was carefully puddled to keep the larger conglomerates back from the surface. This was done with a perforated steel spade, worked up and down on the inside of the forms.

No integral coloring material was used in the concrete, but instead, a brush coat of California stucco, of a color slightly lighter than the natural concrete, was applied. This material is of such thin consistency that it revealed all the original texture of the wall.

The ornamental features in the gables and tower were all monolithically cast by the use of plaster molds which were made on the job and simply nailed up in lieu of wooden forms. Concrete was placed in the usual manner, especial care being taken to work a fine mix into the matrix of the reverse mold producing the ornament.

The architects have several other buildings under construction in which this type of construction is being used and are enthusiastic over both the artistic possibilities of concrete and its low cost of workability. Contractors have no difficulty, beyond a little extra cost and care in form work, in placing the material in the performance of cast buildings of this character.



Properties of Aluminous Cements

A Translation from the Chemiker Zeitung Giving Some Results from Experiments in the Use of High Alumina Cements—Discussion of High Temperatures Generated During Setting Period — Action of Frost on Setting Properties — Volumetric Changes — Relation Between Setting and Hardening—Resistance of Aluminous Cements Salt Solutions

American engineers have as yet had only limited experience in the use of high alumina cements and there are still many questions as to its behaviour under varying conditions. The more general use of these cements in Europe has resulted in comprehensive studies of their properties. Tests and experiments have provided data from which the behaviour of aluminous cements under given conditions can be explained and predicted. In the following article the results of a number of such tests are analyzed. They will be of value to American engineers as a check on their own experiences.

A CONSIDERABLE heating effect goes hand in hand with the extraordinarily rapid setting and hardening of aluminous cements. From the curve (Figure 1), it can be seen that the heating effect sets in right after setting of the cement begins and reaches a maximum after a certain interval after setting is completed. This property of spontaneous heating during setting gives aluminous cements entirely different properties than those of ordinary portland cements in which heat has only a very slight effect at the most. For this reason aluminous cements can be used in temperatures below the freezing point, in winter weather or in refrigerators and the like. This fact has been taken advantage of in the practical use of the aluminous cements, for the heating effect acts to such a degree in the concrete mixture as to assure the proper setting of the cement under these conditions.

Tests in Low Temperatures

Tests have been made in which the action of this thermal phenomenon on the properties of the set of the cement has been studied. Thus samples of the cement were allowed to set at temperatures as low as 6 degrees C., and then allowed to remain in a room in which the temperature was as low as 18 degrees C. for a period of twenty-four hours. The samples were then tested for resistance to compression and were found to give results as high as 466 to 512 kilograms per square centimeter.

Other tests were also made in which the test samples were allowed to set in iron molds subjected to low temperatures. The temperature chosen was minus 6 degrees C. Thereafter the samples were removed and allowed to thaw out at a temperature of 18 degrees C. and then tested at definite intervals. It was found that the resistance to compression at 24 hours after thawing was 107 kilograms per square centimeter and at the end of forty-eight hours it was 400 kilograms per centimeter.

The results clearly indicated that the test samples were not completely set but had just attained initial strength and that the real strength was developed only after they had been allowed to stand for a longer time. Inasmuch as this result is not expected from the study of the temperature curve, given above, and also contradicts certain experience in practice, it must be concluded that the experiments were in error. When it is considered that the heat effect in the aluminous cement starts at the beginning of the set and that this is approximately three hours after the sample has been made up, it must be assumed that the action of the frost has penetrated quite far into the samples, so that the greater part of the water used in making the cement is present only as ice and hence no hydration can take place. On the other hand if the mass of the sample is sufficiently large with respect to its surface area, in order to resist the penetration of the frost up to the beginning of the set, then the heat of setting of the aluminous cement begins to work against the action of the frost, the water remains liquid and complete hardening takes place.

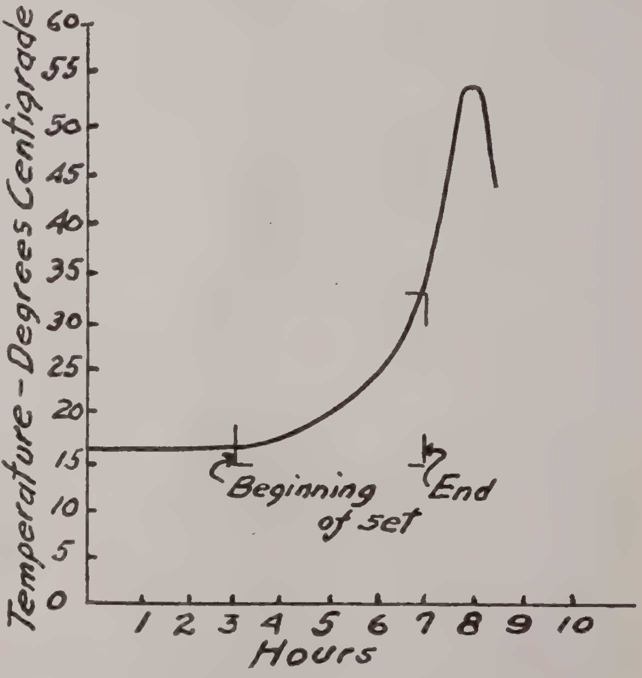


Fig. 1

Tests on Larger Samples

To determine the truth of this contention a number of samples were made 30x30x30. These samples were formed of sand, cement and water at a temperature of 18 degrees C. Two samples were made in which a thin glass tube was imbedded, reaching to the center of the sample. The tube was filled with mercury and served as a thermometer. Both samples were immediately subjected to the action of frost, after they were made up. One of these samples was taken from the form while the other was left in the form.

The results showed that the sample which was removed from the form showed a layer of friable, moist cement of one half to one centimeter in thickness on its surfaces, with the exception of the bottom surface, but had otherwise set through and through. The second sample, which was left in the form was completely hardened and when struck with a hammer gave a clear tone. The strength of this sample in compression was 398 kilograms per square centimeter.

It must be said that this property of aluminous cements also has its disadvantages. The height to which the temperature within the aluminous cement block will rise depends on the external temperature and, as the latter increases the former will naturally increase. This has the effect of increasing the expansion of the cement block. Thus, when aluminous cement is used for applying a plaster coat in the summer time on a very hot day, the bond between the pure aluminous cement and the underlying surface takes place when the former has expanded to its maximum point due to the evolution of heat. After the plaster cools off, it naturally contracts and strong stresses are produced which result in cracking and loosening up. When this first occured in practical work, there was no way in which it could be explained, until a number of researches were made. Tests were made with carefully prepared samples of the mortar which were used to cover concrete blocks and these tests showed conclusively that the cause of the splitting and cracking of the cement was due to expansion caused by heat.

It must be remembered, however, that these difficulties have nothing whatever to do with the constancy of volume of the aluminous cement block, for this type of concrete retains its volume under all conditions. They are due primarily to the great amount of heat developed during the setting of the cement. It is possible to counteract this effect to a certain degree by making the concrete mixture a lean one, but here again there is a definite limit beyond which it is not practical to go.

It should also be mentioned at this point that aluminous cements, not considering the action of carbon dioxide, appear to be very resistant to the influences which tend to disturb the proper setting of ordinary cement. A test was made in which the water used to make the mixture was saturated with sodium chloride. Under these conditions there was no sign that the setting of the cement had been disturbed in any manner, although solid particles of salt were found in the hardened samples. The setting was perfect and the particles of salt were simply surrounded with hardened concrete.

Volumetric Constancy

It has been said that aluminous cement samples keep their volume perfectly. Thus when the test sample was subjected to the action of water and air for a period of twenty-eight days, no cracks or other changes in volume took place. The same is true of a test made with spherical samples of the cement heated to incandescence and with a sample subjected to the action of boiling water. The same favorable results were also obtained with the very severe Le Chatelier test in which a small brass cylinder, which is cut open lengthwise and carries a pointed index on either side of the slit, is filled with cement and then allowed to remain for twenty-four hours in cold water, after which it is boiled for five hours in water. There was no expansion of the slit except to the extent of two millimeters, measured between the two points. It is generally considered that the volume of the cement remains constant if the distance separating the points is five millimeters.

Rapid Hardening

The often repeated contention that aluminous cements are rapid setting is entirely erroneous. Quite the contrary, these cements set just as slowly as portland cements. But it can truthfully be said of aluminous cements that they harden rapidly. Correctly proportioned aluminous cement sets under normal conditions within a period of three to seven hours. This is important as far as the use of these cements for building purposes is concerned.

It is true that aluminous cements possess the property of setting slightly directly after they have been made up and due to this action their appearance is dulled, but the completion of the setting process takes place only after several hours have elapsed. This phenomenon takes place when too little water is added to the cement, for when the correct amount of water is used the setting of the cement is entirely normal. It should be mentioned that in using aluminous cements it is important that more water be used than in the case of portland cements.

Furthermore, inasmuch as aluminous cements wet down with more difficulty than portland cements, a thorough mixing and kneading of the mortar composition is of the highest importance in securing good results. Wherever it is possible and wherever it does not interfere with the building operations, it is advisable to mix the mortar in the dry state first and then to add the water. It is essential that the aluminous cement be kept uncombined with other cements under all conditions, for if mixtures are made the setting of the cement is not perfect and the strength of the hardened concrete is far from what it should be.

Resistance to Salt Solutions

Considerable time has been spent recently in the investigation of the resistance of ordinary cements to the action of solutions of various metallic salts, particularly of ammonium salts. Experiments were undertaken to determine the effect of solutions of these salts on aluminous cement. Thus five per cent solutions of ammonium sulphate and ammonium chloride, ten per cent solutions of ammonium carbonate and of ammonium nitrate were experimented with. The results were compared with those secured with portland cement.

It was quite surprising to find that when a sample of aluminous cement was permitted to remain in the five per cent solution of ammonium sulphate, the strength of the cement did not diminish. This is entirely contrary to experience with portland cement, for when a sample of this product is allowed to remain in a 5 per cent ammonium sulphate solution for a period of three months, the tensile strength was reduced to 3.5 kilograms per square centimeter. On the other hand the resistance of the aluminous cement both to tension and to compression was not affected in a material way after a period of six months had elapsed and at the end of that time amounted to 39.8 and 695 kilograms per square centimeter respectively.

The same conclusions were reached in the case of aluminous cement samples submerged in a solution of five per cent ammonium chloride. There seemed to be a slight but constant increase in the strength of the samples. In the case of the ten per cent solution of ammonium carbonate, it was found that the resistance of the samples to compression increased considerably and amounted to 871 kilograms per square centimeter at the end of a six month period, while the resistance to tension fell within the period of three to six months' exposure from 47.7 to 45.2 kilograms per square centimeter. This is, of course, but

(Concluded on Page 50)

Pacific Coast Building Officials Writing Uniform Code

Existing Building Code Problems Discussed — Code to Be Submitted for Approval at Conference—Importance of Uniform Codes—Inspection at Owners' Expense—Special Provisions for Design Against Earthquake Shock

THE building inspectors of the Pacific Coast are industrious as well as progressive. Seated around a long table in an interior room of a Sacramento hotel, on chairs that hourly grew harder, inspectors representing twenty cities spent five days of the last week in May discussing and revising their proposed uniform building code.

The draft then under discussion follows to a considerable extent the outline in the report on "Recommended Practice for Arrangement of Building Codes," issued in 1925 by the Department of Commerce Building Code Committee. Some modifications of that outline were found necessary. Actual preparation of this draft has been largely in the hands of A. C. Horner, chief inspector of Stockton, California, who acted under the authority and direction of the executive committee of the Pacific Coast Building Officials' conference. Mr. Horner, a graduate in civil engineering of the University of Pennsylvania, has been head of the building department at Stockton for four years. The meeting in Sacramento constituted one of his last official participations in the preparation of the proposed uniform code, due to his resignation from his position at Stockton, effective June 1.

The Proposed Code

The proposed uniform building code constitutes the principal reason for the existence of the Pacific Coast Building Officials' conference, which will hold its fifth annual meeting in San Jose, California, from September 20 to 23. The code is intended primarily as a document suitable to the needs of Pacific Coast cities, although with very few exceptions its features would be applicable to cities in any other section of the country. The building regulations are designed to produce a high degree of structural safety. There is the further purpose of obtaining uniformity, arising from the knowledge that lack of uniformity in the basic requirements of city building codes causes confusion and waste. Materials or methods permitted in one city are prohibited in a neighboring city, or else their use is hampered with unnecessarily severe restrictions.

The Santa Barbara earthquake of June, 1925, and the lessons it taught on the value of good construction, furnished the final stimulant that made the uniform code financially possible. The city councils of about twenty cities appropriated small sums to defray the expenses that are necessarily involved in this undertaking.

It is expected that the final draft of the code will be adopted at the annual meeting in San Jose, following which it will be printed. The Pacific Coast Building Officials' conference will have possession of the type and plates, so that even cities not now taking part in the financial support of the project may nevertheless obtain use of the code at a cost considerably below the cost of a separate printing. A moderate appropriation to cover the cost of clerical work and necessary typographical changes will be the only financial support expected. This is a matter of particular interest to building inspectors who have been unable to induce their city councils to contribute funds in advance of tangible evidence that a code actually would be forthcoming.

Code Features

The code in its present form avoids detailed specifications so far as possible. It follows closely along the fundamental principles of structural engineering. It provides for the use of all materials and methods of construction that have proved their fitness, and leaves the door open to new materials and methods that may be developed in the future. The arrangement of the uniform code, while subject to change, now comprises one classification of buildings into various kinds of occupancy, a second classification based on location in so-called fire zones, and a third based on types of construction. The requirements of the law, which are necessary for public health and safety, are based primarily on these three classifications.

An apartment building, for illustration, must be planned and designed in accordance with certain requirements that have particular reference to the use of the structure as an apartment building. It must be located in a certain way with respect to the lot lines. Other regulations deal with stairs and elevators and their enclosing walls, still others deal with light and ventilation, with fire-extinguishing apparatus, and so on. Certain modifications in some of these regulations will depend on whether the building is located in Fire Zones 1, 2 or 3. Other modifications will depend on the type of construction.

Fire Zone 1 will in general comprise the central business district of a city. Buildings in Zone 1 must be built so as to possess a fairly high degree of fire resistance. Zone 2 will include the close-in areas immediately surrounding the central business district, in which restrictions will be less severe than in Zone 1. The remaining area will be in Zone 3, with restrictions least severe.

Classification of Types

Based on types of construction, the present draft of the code classifies buildings as follows:

Type I—Fireproof (reinforced concrete and fireproofed structural steel).
Type II—Incombustible construction.
Type III—Heavy timber construction.
Type IV—Skeleton construction.
Type V—Ordinary joisted construction.
Type VI—All-metal construction.
Type VII—Wood frame construction.

While these classifications are also subject to change, it is not probable that any essential rearrangement will be made in the final draft.

Other parts of the code cover administration, definitions, engineering regulations, quality of materials, details of construction, fire-resistive standards and regulations governing use of streets during construction.

Materials in which our readers are interested are given fair treatment in the proposed uniform code. Concrete masonry units are accorded virtually the same treatment as solid units. They will be permitted in foundation walls of all structural types except Types I and II. In the superstructure they will be permitted in the exterior walls, fire walls and fire division walls of all types. Concrete units are listed also among the approved materials in the chapter on fire-risistive standards, where the required construction is specified for 4-hour, 3-hour, 2-hour and 1-hour fire protection. Metal lath and plaster and monolithic concrete are also given proper consideration in this respect. Hollow concrete units are given approval for use in fireproof partitions, exterior panel walls, fire walls and other locations for which they are well suited but from which any city codes now exclude them.

Inspection

Considerable discussion arose over the question of whether to adopt the joint committee report on concrete and the specifications issued by the American Institute of Steel Construction by reference, or whether to prepare complete chapters covering these materials. From the fact that these two types constitute the greater part of the structural material used in important buildings it was decided to write out complete chapters in both instances. It was in this connection that a discussion came up regarding private inspection of structures at owners' expense, a subject that was given much prominence at the twelfth annual meeting of the National Building Officials' conference in Columbus, Ohio, held late in April. The final decision follows somewhat along the requirements of the Seattle building code adopted in 1924. That is, owners of important structures who elect to furnish private inspection satisfactory to the head of the city building department will be permitted to take advantage of the working stresses recommended in the two reports mentioned above. Owners of less important structures who do not care to provide such inspection must have their buildings designed for more moderate working stresses, approximately 15 per cent lower than in buildings where inspection is provided.

This method of disposing of the knotty problem of better inspection without additional expense to the city has been found satisfactory in Seattle, and there is no reason why it should not be feasible elsewhere. It will at least insure constant inspection of a high quality on the larger and more important structures. Unfortunately, it still leaves the more speculative structures, where inspection is most needed, with only the meager inspection provided by the city building department, unless by chance the mortgage loan company behind the project requires competent inspection for its own protection. In any event it is a step in the right direction, and will do much toward proving the value of engineering inspection for all sizes and types of buildings.

Special Provisions

Regulations providing for design against earthquake shock will be printed in the appendix, with directions for incorporation in the body of the code in cities considered to be in an earthquake zone. The Palo Alto ordinance, which has been accepted by the Hoover building code committee in its report on unit stresses in timber, steel and concrete, will be followed. That ordinance utilizes either the surface area method or the acceleration method, whichever produces the greater computed stress.

Six or eight Pacific Coast cities, among the largest of which is Sacramento, are now waiting to adopt the uniform building code as soon as it has received the final sanction of the building officials themselves. In all probability many of the smaller and medium-sized cities in the Pacific Coast region will follow their example.

Properties of Aluminous Cements

(Continued from Page 47)

a slight drop. Parallel experiments carried out with portland cement showed a slow but steady increase in the compression strength of the cement, while the resistance to tension dropped within the period of three to six months only a very little from 41.8 to 41.3 kilograms per square centimeter.

On the other hand the results that were obtained with the samples of cement that were subjected to the action of the ten per cent solution of ammonium nitrate were very unfavorable. The curve showing the strength of the aluminous cement shows a constant decrease even after a short period of exposure to the action of the nitrate. Although it has been found that the aluminous cement behaves much more favorably in this respect than the regular portland cement, nevertheless it must not be considered in any way as being resistant to this chemical. The portland cement sample had a strength in tension of only 3.8 kilograms per square centimeter after a period of three months.

Resistance to Sulphates

One of the principal advantages that have been claimed for aluminous cements is their resistance to the action of sulphate-containing waters. It has been held that aluminous cement is affected considerably less slowly by sulphuric acid in the free state than is portland cement. Furthermore, it is not only indifferent to the action of a five per cent solution of ammonium sulphate, but in fact its strength is materially increased.

Further tests have been made along these lines and samples of the cement in conjunction with comparative samples of portland cement have been subjected to the action of a five per cent solution of potassium bisulphate, a seven and one-half per cent solution of magnesium sulphate and a ten per cent solution of sodium sulphate as well as a saturated gypsum solution.

The results proved the truth of the above contentions for in no case was the aluminous cement attacked by the sulphates. On the other hand the portland cement is soon affected by these salts and its strength is materially reduced. This is particularly true of the resistance of the cement to tension.

Resistance to Seawater

Much has also been written of the resistance of aluminous cements to seawater and to gypsum solutions. Tests have been made with samples of the pure cement and these have been allowed to harden for a period of several weeks. Then the cement samples were pulverized. Gypsum was also pulverized in the same manner. A mixture was then made of fifty per cent gypsum and fifty per cent of cement, and small cylindrical samples were formed of this mixture. These were finished under pressure. The samples were then subjected to the action of air saturated with moisture and covered with a sheet of filter paper, whose end dipped into a pan of water. The entire experiment was then covered with a glass globe. While all other samples of cement tested in this manner showed swellings and cracks within a very few days, the aluminous cement samples were the only ones to remain unchanged. Even after a period of two years' exposure they did not show any change.

Numerous other tests have also been made to determine the resistance of aluminous cements to the action of sea water. These have given results which indicate that this kind of cement is particularly well adapted to use for submarine structures.

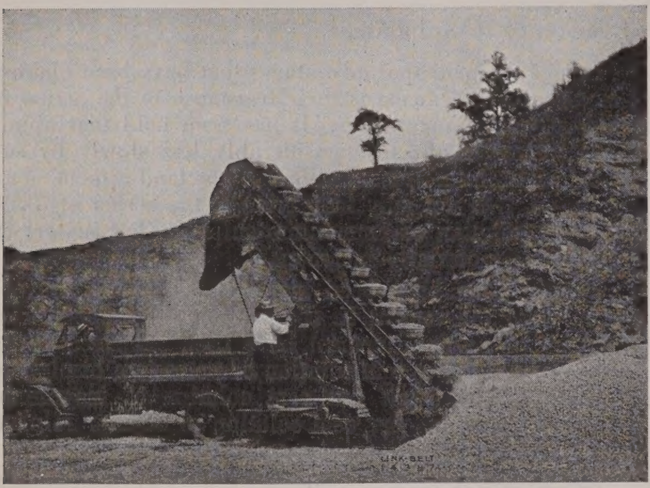
New Equipment

Link-Belt Company Announce New "Grizzly" Loader

A new crawler loader, known as the "Grizzly," has just been announced by the Link-Belt Company, of Chicago, Philadelphia, and Indianapolis.

This machine contains all that company's latest developments and improvements, in design and detail of construction, and is said to handle crushed stone, gravel, sand, and like materials at the rate of 1¾ yards per minute,—or about 140 tons per average hour.

This new crawler loader is a one-man machine. Its driving, its operation, and its care can be handled entirely by one worker of average intelligence. Four units compose the loader, i. e., the elevator, the chassis, the power plant, and the crawler; the unit system of construction enabling the operator to inspect the machine easily, and to make any adjustment or repair without tearing the whole machine apart.



This new Link-Belt loader is reputed to handle 1 3/4 cubic yards of aggregate per minute

Special attention has been given to the lubrication of all moving parts, all of which are provided with Alemite fittings or grease cups placed within reach of the operator. All bearings and moving parts are large enough to keep wear to a minimum, and give longer life to the loader.

Motor Trolley for Small "Lo-Hed" Hoists

A new motor-driven trolley has been developed by the American Engineering Company, Philadelphia, for use with its half-ton and one-ton Class A, "Lo-Hed" electric hoists, which have been built, heretofore, in bolt suspension and plain trolley types only.

The trolley can be supplied with travel speeds of 80 or 120 feet a minute, so that the trolley and hoist provide an inexpensive overhead system for handling loads of one ton or less at high speed, both in lifting and moving. Its accurate control makes it handy in moving molds and concrete units, such as lamp posts, etc. It can be arranged for remote control if desired.

Improved Mixing Blades Increase Kent Mixer Efficiency

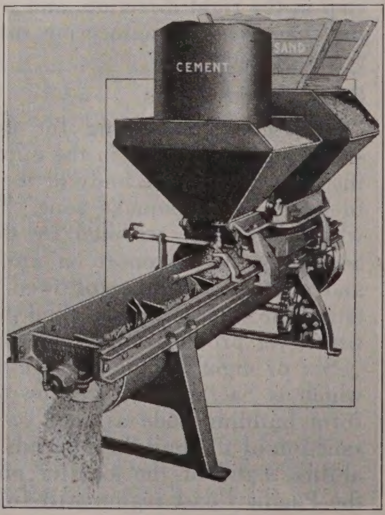
An improved mixing mechanism that speeds the production of a better mixed concrete is an interesting feature of the present models of the continuous products plant concrete mixers manufactured by the Kent Machine Company, of Kent, Ohio. The material is cut, turned and returned 1800 to 2500 times a minute by means of paddles revolving 70 times a minute. These paddles, chill hardened, are bolted to a square shaft and can be easily adjusted or removed without disturbing the others simply by loosening the bolt. The entire paddle shaft can be removed for cleaning the trough by loosening four bolts. The amount of cement in proportion to the sand is controlled by an adjustable opening at the delivery end of the cement hopper. This opening can be varied and the proportion changed almost instantly by simply loosening a hand wheel and changing its position on a slotted clamp rod. A graduated scale and pointer serve as guides in making quick and accurate adjustments. On machines equipped with three hoppers both the sand and cement hoppers are equipped with this feature.

The hoppers are equipped with wearing strips which may be adjusted to compensate for wear by loosening two cap screws on each strip and moving it closer to the feed plate. The output of mixed concrete can be varied instantly, without stopping the mixer or altering the proportion, by moving a hand lever on a variable yoke. This enables the control of the output of the mixer to suit the production of the plant.

The material is mixed dry as it moves through one-half the length of the trough. At a central point the water is added and wet mixing continues as the material moves on to the discharge end. Water flows continuously, the volume being controlled by a valve. On three-hopper mixers a second water pipe is supplied for the purpose of wetting the stone before it enters the trough.

All of the important moving parts are carried on self-aligning bearings, of the ball and socket type, which are easily and quickly removed and replaced. The bearings are fitted with accessible oil tubes which have caps to exclude dust and dirt.

This is the new model Kent mixer with its mixing blades that are more efficient than to be found on the older models of continuous mixers



Mixer Musings

Reported by "Joe"—The Mixer Boss.

And They Wondered Why

"Did you ever stop to think," said my old friend Sam as he breezed into the shack the other day, "that this business of building concrete houses is being slowed up by many a crazy guy who picks up an idea from some crazy inventor and starts out to show the world—with nothin' to show 'em? Then the work goes bad, the costs prove high, and another town has sworn off of concrete houses? —Course there are a number of systems that've panned out, but this was one of those that've proved all haywire."

I knew that Sam had something on his mind, so knowin' him like I do, I said nothin' till he had planted himself down on a nail-keg and got the old corncob goin' like an switch engine. Sam, who'd come up from a gandy-dancer to a concrete boss in but twenty years' time, was addicted to fuel for his old hod that 'ud make a polecat sneeze—Puddler's Delight, it was called, or somethin' like that. Anyway, when he'd got the shack nice an' fragrant an' I was just startin' to open the window a little, or call for the pulmotor, he opened up a little kindof as follows:

"You know," says Sam, "I was just flivverin' back from the fishin' place the other day when I came across one of those birds runnin' up a wall way out past the edge of town. He'd picked up a set of some sort of molds somewhere, and got hold of some sort of a trick concrete mixer, and was tryin' to surprise the owner of the crossroads site with a concrete house cheaper than brick.

"Well, anyways, this guy had found a bunch of sand that was all silt and mud and the Lord knows what, and he'd found some cement that the dealer was willin' to sell cheap since it had been layin' around for several years back in the corner of a shed, and he got a half-wit to tend the mixer—cause he only wanted a dollar a day, and here he was runnin' up the wall with nothin' as much as a line to guide him. He'd load so many shovels of sand into the mixer, then dump in half a sack of cement, and then stick the hose in the mixer and let 'er run for a moment, and then set the thing to turnin' and pretty soon he had a batch of stuff. He was usin' a dry mix, and tampin' it into the mold with a thingamajig that looked kind of like a potato masher, and he would then strip the mold and put in some material.

"When I asked him how much the work cost, he figgered a minute and then said that she would run about the same as any other masonry. With that I climbed down and went around to one side of the job and leaned against it, kind o' careless like, just to see what I could see, when darned if the blame thing didn't start to wobble—stuff that evidently had about a month to set.

"Then I noticed how the wall had broken off around a window opening and was otherwise showin' about as much strength as if it had been made of nothin' but plain dirt.

"You can bet I got out of there pretty quick before somebody I'd know 'd come along an' think I was workin' on such a crazy job."

I'd have done the same.

If you've a great idea that will revolutionize home building, better read up a little first. Maybe another guy proved it wouldn't work. You might be surprised.—***Joe,*** *the Mixer Boss.*

News of the Industry

With the Manufacturers

The new No. 28 Saw Rig, recently announced by the *C. H. & E. Manufacturing Company,* 254 Mineral Street, Milwaukee, is described in an interesting folder just received. This saw rig, designed for the average contractor, is a portable affair powered with a two cylinder 8 hp. LeRoi gasoline engine. It has a ripping capacity of 4 in., and operates with a 16-in. planer saw or rip and crosscut saw. The entire outfit weighs 1000 lb.

The Monolith Hollow Wall Company is the new name just authorized for the firm formerly known as the Johnson Hollow Concrete Wall Construction Co., Inc., located at 634 South Western Avenue, Los Angeles, Calif. That concern will hereafter be known by the new name, but will continue at the old address. There have been no changes in personnel or management.

At the recent meeting of the stockholders and directors of the *Fuller & Johnson Manufacturing Company,* Madison, Wis., the following officers were elected: C. L. McMullen, formerly vice-president, president and director of sales; W. W. Gore, vice-president, director of engineering; C. K. Swafford, vice-president, director of production; H. C. Wolf, treasurer, director of purchase; Paul Kney, secretary, director of credit and finance, and M. J. Esser, assistant treasurer, director of accounting. The above officers constitute the board of directors.

C. L. McMullen began his career with the Fuller & Johnson Manufacturing Company in 1902. In 1912 he was appointed sales engineer, from which he advanced to general sales manager, vice-president and director of sales and now to his present position as president of the company. With his broad engineering and merchandising experience in the industrial field, he comes well fitted to assume the added responsibility as head of the concern. *W. W. Gore,* vice-president and director of engineering, recognized as one of the leading gas engine designers, is responsible for many patented features embodied in the design of the new Fuller & Johnson engines. *C. K. Swafford,* vice-president and director of production, is well known as a production engineer. In 1920 he was appointed general superintendent from which he has advanced by recent election to vice-president and director of production. The company during the past year has added several new sizes and types of gasoline engines. These developments which have materially broadened their line, account in a large measure for the very substantial increase in their business this year.

The Sanderson-Cyclone Drill Company, with offices and works at Orrville, Ohio, has purchased the Motor Division of *The Wellman-Seaver-Morgan Company,* of Cleveland, Ohio. By this purchase the manufacturers of a line of mining, quarrying, construction, and well machinery and tools, have added a gasoline engine to their line. The engine is a four-cylinder, four-cycle, valve-in-head type motor, with a 4¾ in. bore, 6 in. stroke, and develops 28 hp. at 600 rpm. up to 56 hp. at 1400 rpm. It contains a number of features that should make it a good motor for construction equipment requiring that amount of power.

Joseph T. Ryerson & Son, Inc., have taken over the *reinforcing bar division of the Penn Metal Company of Boston.* They will immediately add to the sizes and tonnage carried. The facilities will also be increased and many features added in accordance with the standards of Ryerson Steel Service. General sales offices have been opened at 677 Concord avenue, Cambridge. A complete staff of engineers and draftsmen will estimate and quote on the steel reinforcing requirements of all types of construction. For many years the Ryerson company has served the steel consuming interests of the East through their plants at Jersey City, N. J., and at Buffalo, N. Y. Other territories are reached from their plants in Chicago, Detroit, St. Louis and Cincinnati.

At the annual meeting of the Concrete Products Association (Canada) held in Toronto recently, the following officers were elected for the current year: W. H. Edwards, Woodbridge, Ont., president; F. J. Kinzinger, Windsor, first vice-president; W. H. Kelk, Toronto, second vice-president; C. R. Christie, Toronto, treasurer, and H. W. Thompson, Toronto, secretary. Directors elected were George Lawrence, Stoney Creek; L. Wookey, Toronto; T. W. Bishop, Ridgeville; Wm. Theaker, Hamilton, and R. J. McLelland, Kingston.

New Books

"Pilzdecken"—"Flat Slabs," by Dr. of Eng., Dr. Lewe, a consulting engineer in Berlin, is an elaborate recapitulation of the same author's work, "Die Strengs Loesung (des) Pilzdecken Problems."

"Strange Loesung" to foreign students means "strictly theoretical solutions," and Dr. Eng. Lewe in his book seems to top such experts as Groshof, the great mathematician, Prof. Henry T. Eddy of Minneapolis (the Turner exponent), Max Mayer, and also criticizes Profs. Hager and Foppl-Ritz.

Using the Fourier rules of progression, the author, by integration of the differentials, obtains a general solution of the theoretical flat slab problems—and embodies this solution in tables for a large number of load-positions.

Whether the intrinsic theoretical gain is worth while, in our American practice, remains to be seen, but the intense tendency to efficiency by proper research is fascinating to the student of evolution in engineering—and "Pilzdecken" is a sign of a future engineering development in the right direction.—E. Lee Heidenreich.

Industrial Literature

"Clark Theory of Labor Economy" is the title of an unusual booklet that has just come in the mail. Written by Eugene B. Clark, founder of the Clark Tructractor Co., Buchanan, Michigan, it presents in clear language the situation now facing the employer of unskilled labor. The ever-mounting expense of using man as a burden-carrier is well explained, while the theory of the utilization of machinery to eliminate the unnecessary use of manpower is carefully developed, and the profitableness of labor-saving machinery is demonstrated. Mechanical transportation of materials as compared to manual transportation, or handling, is discussed in an interesting manner. While written for the manufacturer, this booklet would be very interesting to the contractor.

Cement-Lime Mortars, by H. V. Johnson, otherwise known as Technologic Paper No. 308, of the Bureau of Standards, cites tests made last year by the Bureau. It was found that the addition of lime to cement mortars increased the water requirement for the same consistency in proportion to the lime added, that shrinkage is increased by the addition of extra water, that the addition of lime will not generally increase the strength of cement mortars richer than 1:2 by weight, but that increased strengths may be obtained with the leaner mortars, that the addition of some lime increases the density of lean mortars and that the principal advantages of the use of lime are an increase in workability and a reduction in cost. Copies of this paper may be secured at a nominal cost from the Superintendent of Public Documents, Government Printing Office, Washington, D. C.

The *Chain Belt Co.'s* latest mixer catalog has just been received. Especially interesting to contractors, and particularly to those who have used pneumatic tires on trailers, is the spring hung axle, designed to absorb all shocks and eliminate otherwise frequent mixer repair bills.

Details such as the height of charging and discharging, chain drive, and tilting the drum are discussed and illustrated.

The Klamath River Bridge, a reinforced concrete arch structure erected by the *California Highway Commission* as a memorial to the late *G. H. Douglas* of that state, is described in an interesting booklet issued on the occasion of the recent dedication of the structure. The new bridge, crossing the Klamath River at a point where a concrete arch was not at first considered possible, is of a monumental type. Its total length is 1147 feet, made up of five main arch spans each 210 feet long, and two short approach spans at either end. It carries a 21-foot roadway which is 51 feet above the water surface. The job required 9060 cubic yards of concrete, 850,000 pounds of reinforcing steel, 946 foundation piles shod with cast iron points, and two million board feet of form lumber and centering. The cost of the bridge is about $400,000. F. Rolandi, of San Francisco, is the contractor.

Numerous suggestions of interest to constructors are published and illustrated in a newly printed handbook received from the Novo Engine Co., Lansing, Mich. Unlike others, this handbook treats chiefly the actual application of platform lifts and material skips, figuring drum capacities, hoisting and the general handling of materials.

Lift trucks, their uses in industry, and ready adaptability to the requirements of concrete products plants are well described and illustrated in a 16-page booklet recently published by the Barret-Cravens Co., Chicago. A hard-wearing latch, low turnable surface, and easy lift are a few talking points dwelt on. Their Bulletin 104 deals exclusively with lift trucks in concrete products plants and illustrates the suggested handling of 42 standard 8x8x16 in. green blocks at one time, as well as the ease with which the truck may be rolled under the loaded rack.

Organizations

American Concrete Institute; Harvey Whipple, Secretary, 2970 West Grand Blvd., Detroit.

American Concrete Pipe Association; M. W. Loving, Secretary, 111 West Washington St., Chicago.

American Construction Council; Dwight L. Hoopingarner, Executive, 28 W. 44th St., New York City.

American Engineering Standards Committee; Dr. P. G. Agnew, Secretary, 29 West Thirty-ninth St., New York City.

American Road Builders' Association; Wm. H. Connell, President, Miss E. A. Birchland, Secretary, 29 W. 39th St., New York City.

American Society for Testing Materials, C. L. Warwick, Secretary-Treasurer, Engineers' Club Building, 1315 Spruce St., Philadelphia, Pa.

Associated General Contractors of America; D. H. Sawyer Secretary, 1038 Munsey Bldg., Washington, D. C.

Associated Metal Lath Manufacturers; 123 West Madison St., Chicago; Wharton Clay, Commissioner.

Building Officials Conference; Frank Burton, President, J. F. Downey, City Hall, Cambridge, Mass., Secretary.

Concrete Reinforcing Steel Institute; M. A. Beeman, Secretary, Tribune Tower, Chicago.

Concrete Products Association; John E. Powers, President, Sterling, Ill.; D. R. Collins, Secretary, 47th and State Streets Alois postoffice, Milwaukee, Wis.

Iowa Concrete Products Association; H. E. Meier, President; R. L. Gavin, Secretary-Treasurer, 405 Hubbell Bldg., Des Moines, Iowa.

National Association of Building Trades Employers; A. E. Coleman, President, 37th St. & Stewart Ave., Chicago. A. W. Dickson, Executive Secretary, 214 Electric Bldg., Cleveland, Ohio.

National Association of Builders' Exchanges; William F. Chew, Baltimore, President; Earl F. Stokes, Secretary, 15 East Fayette St., Baltimore, Md.

National Crushed Stone Association; J. R. Boyd, Secretary, 751 Earle Building, Washington, D. C.

National Housing Association; Lawrence Veiller, Secretary and Director, 105 East Twenty-second St., New York City.

The National Lime Association; Burton A. Ford, Secretary, 918 G Street, N. W., Washington, D. C.

National Slag Association; H. J. Love, Secretary-Treasurer, 933 Leader-News Building, Cleveland, Ohio.

National Sand and Gravel Association, V. P. Ahearn, Executive Secretary, 1045 Munsey Bldg., Washington, D. C.

Ohio Concrete Products Association; G. M. Friel, Secretary-Treasurer, 2284 North High St., Columbus, Ohio.

Portland Cement Association; William M. Kinney, General Manager, 33 West Grand Ave., Chicago.

Wisconsin Concrete Products Association; A. P. Kuranz, Secretary-Treasurer, 425 E. Water St., Milwaukee.